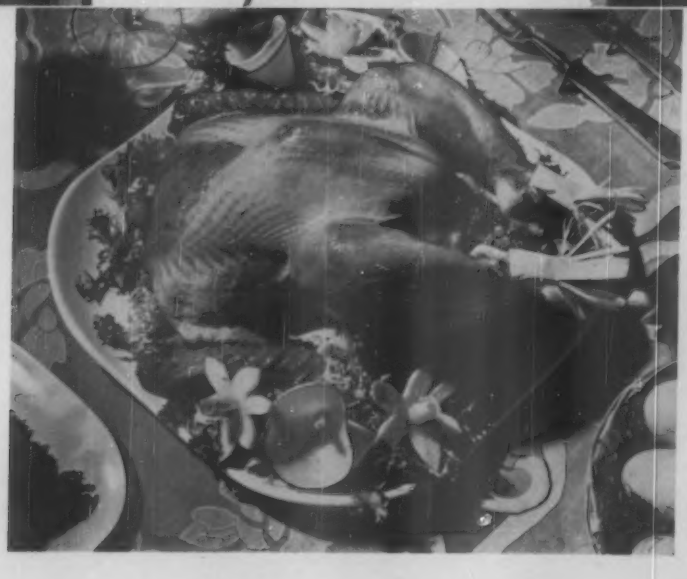
DECEMBER, 1957
Vol. 11, No. 12

FT food technology



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IN THIS ISSUE—

THE TECHNICAL ARTICLES IN BRIEF

Sensory testing *Poultry meat*

Palatability of chickens fed diets containing different levels of fish oil or tallow. L. M. Potter, D. Carlson, L. D. Matterson, E. P. Singsen, G. L. Gilpin, R. A. Redstrom, and E. H. Dawson.

The laboratory study found that chickens fed 1 or 2% menhaden fish oil with or without DPPD had significantly more off-flavor than the controls; those fed 0.5% menhaden fish oil with or without DPPD in addition to the 0.5% in the basal diet were not significantly different from control samples. Where 0.5, 1, or 2% tallow was added to the diet, chickens had very slight or no observed off-flavor. The consumer study found that the addition of 1% or 2% menhaden oil with or without DPPD added to the basal diet resulted in fishy off-flavors; the amount of off-flavor in diets consisting of 0.5% menhaden oil, without DPPD, was similar to that for the basal diets; and othe addition of 0.5, 1, or 2% tallow to the basal diet resulted in no objectionable off-flavors. (See page 615.)

Measurement *Pungency of onion, garlic*

Chemical evaluation of the pungency of onion and garlic by the content of volatile reducing substances. Lionel Farber.

Applicability of the volatile reducing substances (VRS) procedure to quantitative evaluation of the pungency of onion and garlic has been illustrated. Aeration time, concentration of sample and of the alkaline potassium permanganate oxidizing reagent all affected amount of VRS recovered from various onion and garlic preparations; each of these will have to be established, however, to suit particular experimental conditions. Boiling aqueous extracts of dehydrated onion and garlic markedly decreased characteristic odors and the VRS contents. Presence of added sulfur dioxide of 25 p.p.m., or even lower concentrations, could be detected by the increase in the reduction of the permanganate by acidified over that of nonacidified samples. (See page 621.)

Packaging, vacuumized
Ground fresh meat, cured ham

Factors affecting quality of prepackaged meat. II. Color studies. C. Effects of air and oxygen under different pressures upon color of product. John A. Rikert, Lawrence Bressler, C. Olin Ball, and Elizabeth F. Stier.

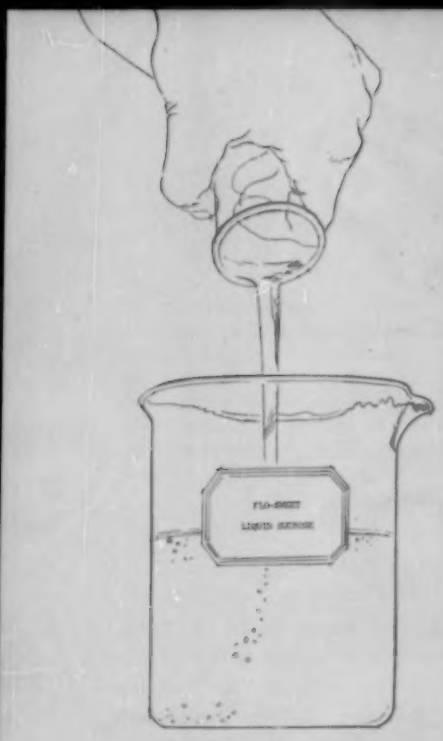
The effect of vacuum variations at constant temperatures was studied. Ground samples of fresh meat and of cured ham were stored in desiccators under different pressures of air while the temperature was maintained constant at 34° F. When fresh meat was stored under a vacuum of 20 inches or more, both the initial loss of redness and the return of redness were more rapid than in meat stored under a vacuum of less than 20 inches. Both increasing the vacuum while maintaining a constant storage temperature and increasing the storage temperature while maintaining a constant vacuum increased the rate of initial darkening and shortened the time for the subsequent return of redness. Vacuum appears to be necessary for the return of redness, but not for the initial darkening. The change in color from grey to red, which occurred in samples stored under vacuum, is apparently reversible. A change can be produced toward either greyness or redness, depending on the absence or presence of high vacuum, respectively. (See page 625.)

Chemical, physical, sensory testing
Frozen red raspberries

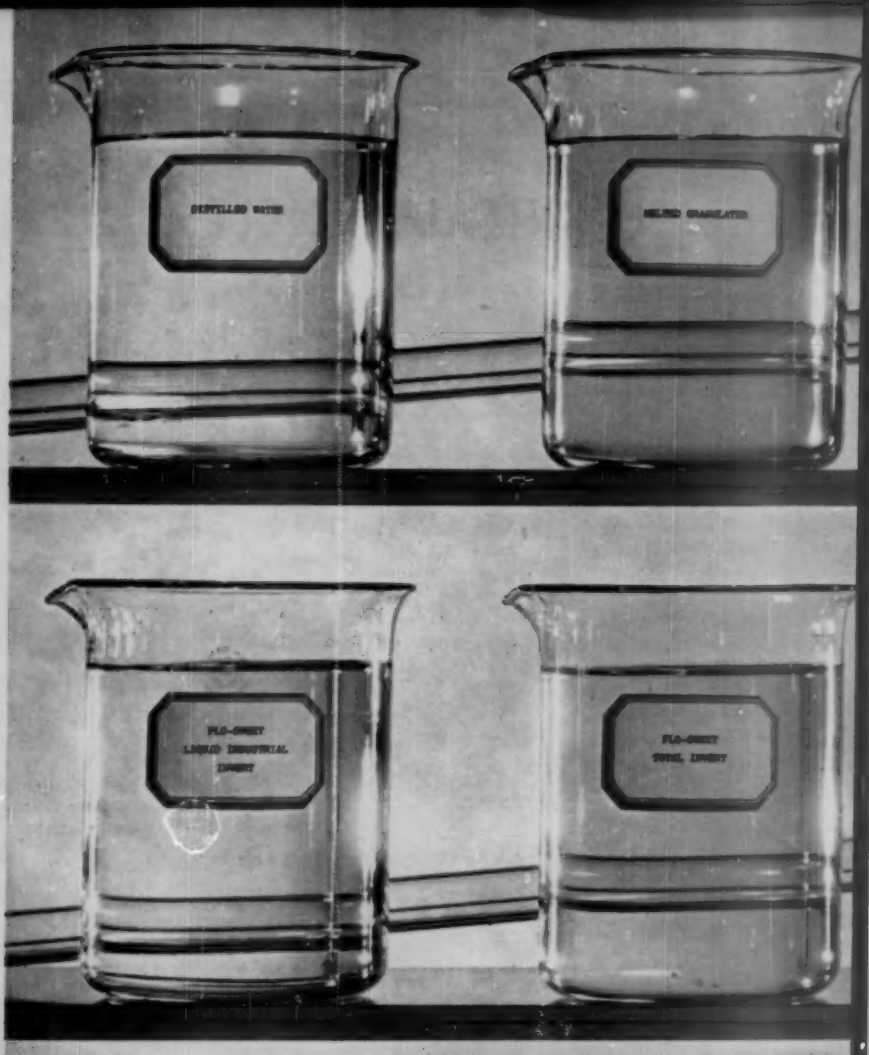
Time-temperature tolerance of frozen foods. X. Retail packs of frozen red raspberries. D. J. Guadagni, C. C. Nimmo, and Eugene F. Jansen.

Sixteen individual lots of commercially packed frozen raspberries, obtained during 4 seasons, were evaluated by means of subjective (color and flavor) and objective tests. Trained laboratory panels found highly significant flavor differences in approximately 90% of these lots within 2 weeks at 20° F. Preferences of the trained tasters and a large group of untrained laboratory tasters were, however, about evenly divided between −20° F. control and stored samples even after 6 weeks of storage at 20° F. Evidence is given to support the hypothesis that the principal reason for ease of selecting the stored from control samples is the migration of acidity from berries to sirup and not necessarily the development of objectionable flavor. Most of the frozen-food quality-control experts who examined samples held at 20° F. for various periods indicated that berries held at this temperature for 6 weeks would not result in consumer complaint. It is emphasized, however, that other fruits such as peaches and strawberries would be seriously damaged under these conditions. It is of utmost importance that distribution practices be patterned to the requirements of the more sensitive commodities. Time required for approximately the same degree of color and flavor change was found to vary exponentially with temperature over the 10 to 30° F. range, and the time required for an equivalent change was increased 2- to 3-fold for each 5° F. reduction in temperature. Color and total acid ratios were found to give good indication of the temperature history of frozen raspberries. The soluble-solids ratio was found to be particularly useful as a thawing indicator. Storage under various time-temperature conditions indicated that color, flavor, and ascorbic acid changes are additive and that the degree of

December Cover. Poultry husbandry and poultry technology and science have greatly extended and diversified the use of poultry products in recent years. In increasing volume products of the highest quality are being prepared, stabilized for storage and distribution, made more and more convenient for household or restaurant use, inspected, and attractively packaged. One of the best of the season's offerings is roast turkey. Photographs by courtesy of Swift & Co. and the U. S. Department of Agriculture.



This color illustration is reproduced from an unretouched 8 x 10 Ektachrome original. The sample of melted granulated shows the color produced by a mixture of *three* commercial granulated sugars. To accentuate the colors for printing purposes, all samples were photographed in 1000-milliliter beakers; an idea of this size can be obtained from the typing on the labels. Below, a precision nephelometer is used to maintain frequent laboratory checks on Flo-Sweet's consistently lower turbidity—a further measure of refinery efficiency and liquid sugar quality.



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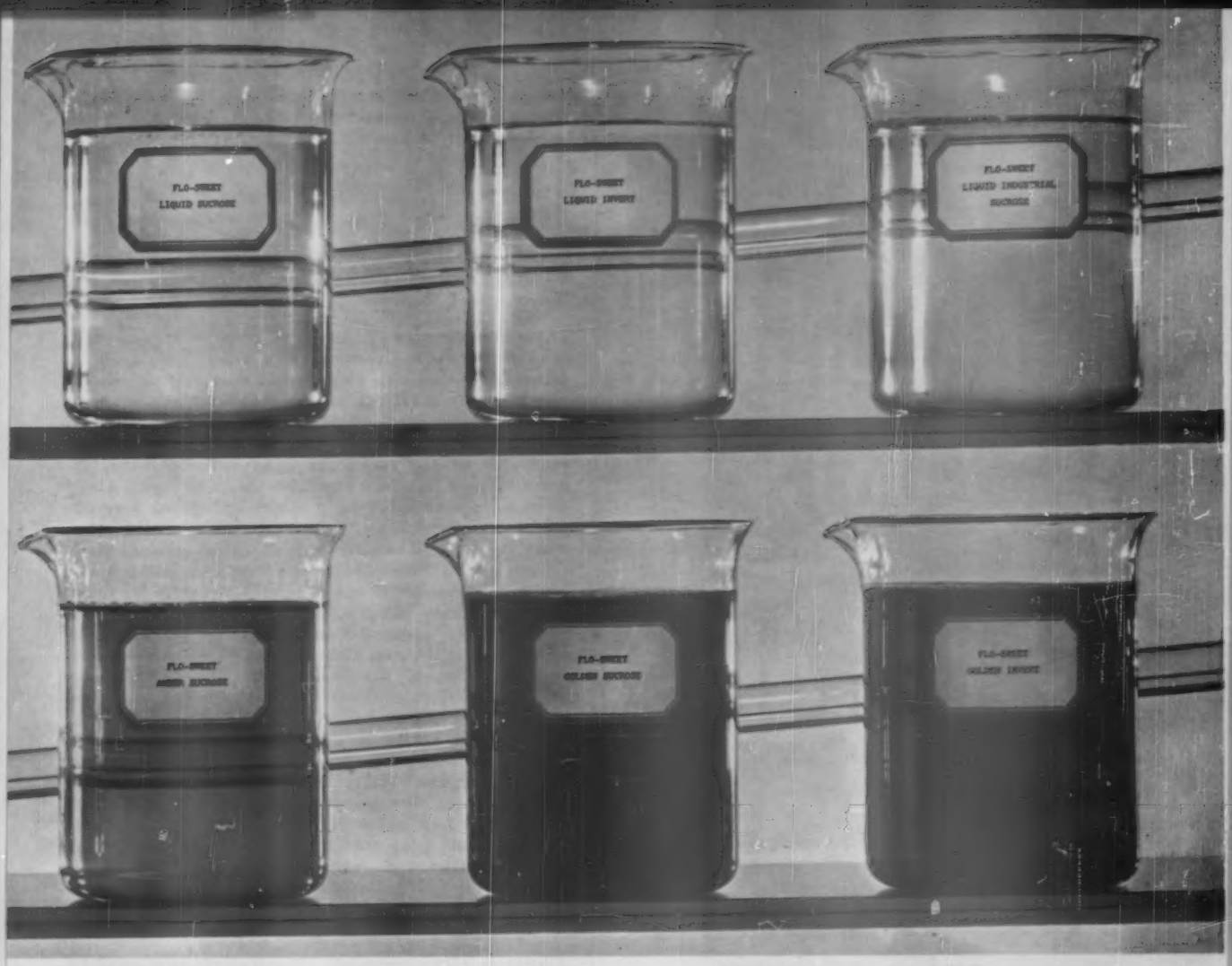

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change is the direct result of the sum of all the time-temperature experiences which the product may have encountered. (See page 633.)

Browning *Canned grapefruit*

Relation of acidity to variation in browning of canned grapefruit sections during storage. R. L. Huggart, F. W. Wenzel, and E. L. Moore.

The relation between some chemical or physical properties of canned grapefruit sections and can-to-can variation in darkening or browning which occurs after long periods of storage under usual commercial conditions was studied. Color, total acidity, soluble solids (° Brix), Brix/acid ratio, pH, ascorbic acid, drained weight, headspace and vacuum were determined for many individual cans of grapefruit sections from several commercial packs. Cans of sections obtained from a commercial plant every 2 weeks throughout a packing season were examined after being stored for 6 months at 90° F.; also examined were cans of 2 packs that had been stored in a commercial warehouse in Florida for 10 and 14 months, respectively. Commercially packed samples, in which the acid level was adjusted by the addition of small amounts of citric acid or sodium hydroxide, were also stored at 90° F. for 6 months and then checked. Results indicated that darkening of canned grapefruit sections during storage occurred more frequently in sections having a high acidity and low pH. Samples with a high Brix/acid ratio did not darken as much as those with a low ratio; however, at a given ratio, samples with lower acidity and lower soluble solids were better in color. Overpacking of cans gave high drained weights, low vacuum, low headspace and resulted in a high acid level and poor color. Degree of browning during storage of canned grapefruit sections did not correlate with ascorbic acid content of products. (See page 638.)

Physical measurement *Sweet corn quality*

Application of specific gravity techniques for the evaluation of the quality of sweet corn. Thomas M. Crawford and Wilbur A. Gould.

Of the specific-gravity techniques studied, it is recommended that the 6-pound method be applied to the fresh cut corn because of its simplicity of operation, inexpensive equipment and large sample size; the 100-g. method is recommended for use with canned and frozen whole kernel corn. Good relationships were shown to exist with the specific-gravity techniques when applied to fresh cut and blanched whole kernel corn. This was also true of the relationship between the specific gravity of the fresh cut corn and the processed product. Values obtained with specific-gravity techniques applied to the fresh cut and processed whole kernel corn showed good relationships with fresh product moisture content and fresh and processed product alcohol insoluble solids. Processed product specific-gravity values were incorporated into nomographs used to determine U. S. Tenderness and Maturity scores of canned and frozen corn objectively. By chemical tests, it was found that total solids, moisture content, alcohol insoluble residue, and total reserve polysaccharides, could be predicted by the use of specific-gravity techniques. Minimum Grade limits were established for values obtained from specific-gravity techniques on fresh cut, canned, and frozen whole kernel corn. (See page 642.)

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Radiation sterilization *Apple slices*

Radiation sterilization of apple slices. R. A. Gillies, A. I. Nelson, M. P. Steinberg, R. T. Milner, H. W. Norton, and Bruce H. Morgan.

Effect of maturity, ripeness, preparatory treatment, and storage on the acceptability of apple slices subjected to various radiation doses was studied. Results indicate that best over-all procedure is to use mature apples, process immediately after harvest, blanch in dilute sugar solutions, vacuum seal, freeze, and irradiate at 0.5 megarep. Under these conditions the apple slices were still acceptable after 6 months of storage at 75° F. When irradiated slices were incorporated into pies along with the usual spices, and organoleptic evaluations were made, effects of irradiation were not as marked as when judged as slices. There was no advantage in irradiating apple slices in combination with spices and pectin in the form of prepared pie fillings. (See page 648.)

Packaging *Pork products*

Container problems associated with the addition of phosphates to the curing ingredients of pork products. B. J. McKernan, R. B. Davis, J. F. Fox, and O. C. Johnson.

Introduction of phosphates as additives to curing ingredients for pork products posed a number of problems to can manufacturers. Packing phosphate-treated product in plain body containers resulted in unpredictable corrosion of the plain tinplate and discoloration of the meat. The simple expedient of using a container enameled throughout with a conventional meat type enamel was not an immediate solution. This paper reviews the search for satisfactory container specifications. Studies of containers were conducted with respect to the relative effects produced by several phosphates and on the possible cumulative effects of these phosphates and the curing ingredients. Investigations were made of the relative effects of sterile versus pasteurizing processes. The role played by product quality with respect to container performance was also examined. (See page 652.)

Stabilization, antibiotics *Poultry meat*

Relative efficacy of three tetracyclines with poultry meat. F. E. Wells, J. L. Fry, W. W. Marion, and W. J. Stadelman.

Three antibiotics—tetracycline, oxytetracycline, and chlortetracycline—were compared at 4 storage temperatures for their ability to extend the shelf life of poultry meat. Chickens were killed, scalded at 140° F. (60° C.) for 40 seconds, mechanically picked, eviscerated and chilled. After chilling and prior to packaging they were treated by immersion in a solution of 10 p.p.m. of the respective antibiotic for 15 minutes. Packaging was done by placing in a cardboard tray and then placing the tray in a polyethylene bag. Storage was accomplished by placing the packaged chickens in coolers held at 0° C., 3° C., 9° C., and 12° C. Spoilage was determined by observing for microbial growth, development of slime, and development of odor. Half birds were used—4 halves for each treatment at each storage temperature. Three replications were made. In addition one series was treated at a commercial processing plant to compare the results obtained there with the results from the University plant. Chlortetracycline was found to be the most effective at all temperature levels, although at the two higher temperatures, differences were small. Effectiveness of all antibiotics was greatest at the lower temperatures. Predominant types of microflora present at the time of spoilage were isolated. Types found on the untreated birds agreed with published findings. A number of the birds treated with the antibiotics were spoiled due to the growth of yeasts, especially at the lower temperatures ranges. (See page 656.)

Statistical quality control *Green peas*

Application of SQC procedures to the canning of green peas. Amihud Kramer and B. A. Twigg.

Statistical quality control procedures are demonstrated as they apply to the selection of reliable growers, sampling inspection of the raw product, control charts on snipping and fill operations, and finished product inspection. (See page 659.)

Flavor technology *Concord grape*

Incorporation of natural fruit flavors into fruit juice powders. II. Concentration and locking of Concord grape flavors. Keene P. Dimmick, Thomas H. Schultz, and Benjamin Makower.

The volatile flavoring component of Concord grape juice was recovered, concentrated, and locked by an experimental procedure. Steps included (1) recovery of flavoring constituents by flash vaporization and rectification, (2) concentration by distillation with a 40-bubble-plate-type column, (3) further concentration by extraction with iso-pentane, addition of rice oil or sesame oil as an ex-

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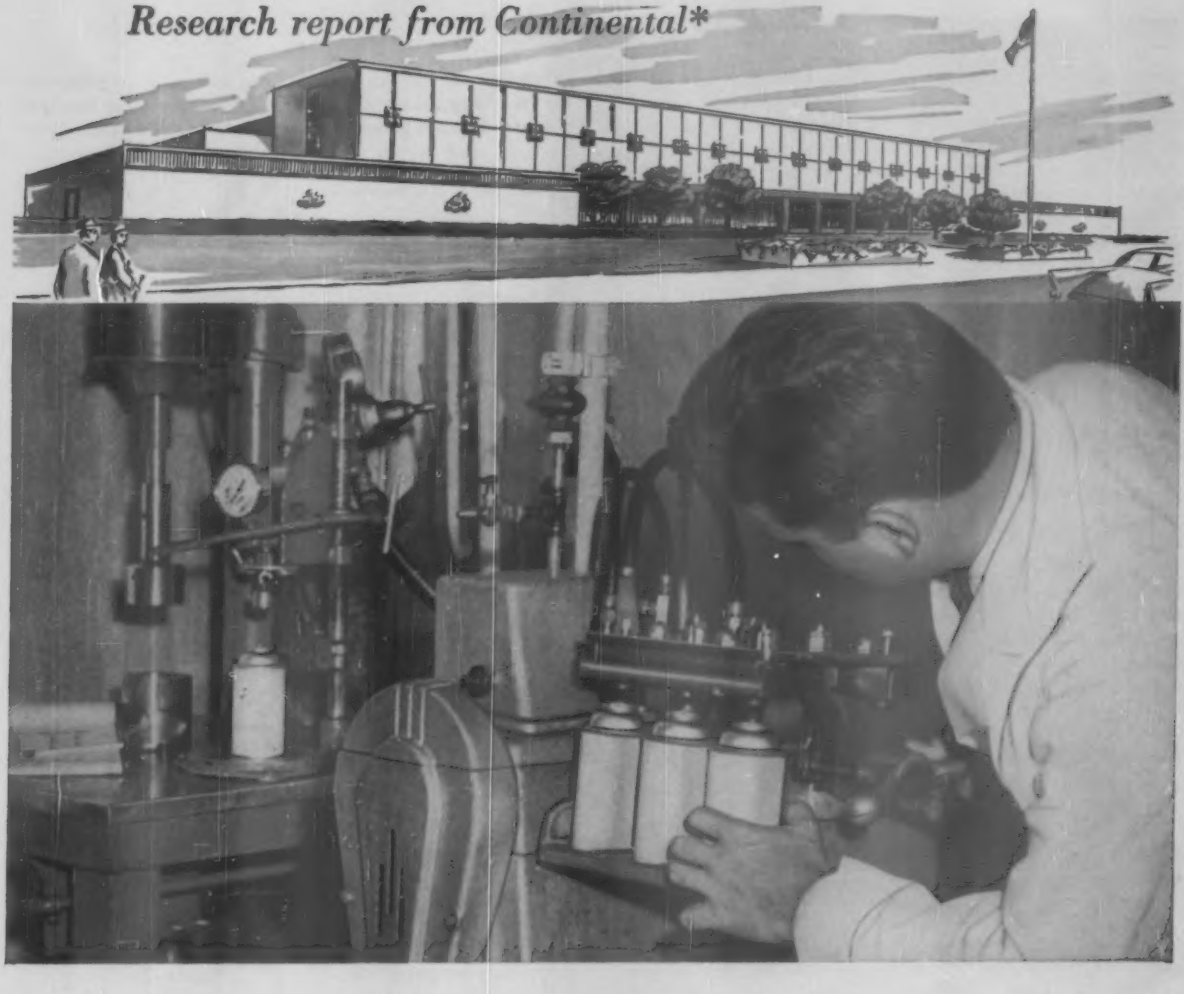

RESEARCH AT CONTINENTAL BREAKS THE "PRESSURIZED FOOD" BARRIER

Look for a new era in pressurized packaging, thanks to Continental research. Previously, the only marketable pressurized foodstuffs were foam products like whipped cream. Now Continental engineers have pressure packaged such foodstuffs as salad dressings, catsup, mustard, meat tenderizers and sauces, table syrups, cake toppings, and chocolate syrup.

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To overcome these obstacles, Continental engineers began sustained experimentation with numerous gas mixtures, with specially designed valve openings and actuators, and with many different food products. Pressurized food containers developed by this research dispense water-base or oil-base food products by means of non-toxic propellants in a spray or stream pattern with a minimum of aeration and product residue.

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tender, and removal of the iso-pentane by distillation, and (4) locking of the non-aqueous flavor concentrate in sorbitol or a sugar mixture. No alteration in flavor resulted from concentration of the flavoring component by distillation up to 330-fold. Locked product improved the flavor of reconstituted grape juice powder, giving juice a more pleasing and natural aroma. Chemical analyses showed low recovery of methyl anthranilate in the first step and low retention of total volatile esters in the last two steps. However, important unidentified flavoring constituents probably came through the process with a better yield. (See page 662.)

Stabilization, chemical *Apple cider*

Preservation of apple cider with sodium sorbate. E. A. Weaver, James F. Robinson, and Claude H. Hills.

Sodium sorbate preserved commercially prepared apple cider for 7 days at a storage temperature of 70–75° F., and for more than 105 days at 50° F., or lower. Sodium sorbate imparts no objectionable off-flavor to apple cider as does sodium benzoate. Sodium sorbate controlled yeasts and molds, but was not effective against bacteria at high storage temperatures. When high bacterial numbers were encountered, sodium sorbate was metabolized and reduced below its effective concentration. Measures which helped to control bacterial growth in cider, such as mild refrigeration or addition of bisulfite greatlyl increased the effectiveness of sodium sorbate. (See page 667.)

Stabilization, antioxidant
Trihydroxybutyrophenone

Trihydroxybutyrophenone—a food grade antioxidant. Ben N. Stockey and W. M. Gearhart.

The physical and chemical properties of a new food approved antioxidant are described. The activity of this butylated phenol in various fats, oils and polymers is shown. Suggestions are also made for practical application and data are given on its effectiveness. (See page 676.)

Consumer preference testing *Ice cream*

The influence of sugar in vanilla ice cream. I. Consumer preferences. Rose Marie Pangborn, Marion Simone, and T. A. Nickerson.

Over 6,000 consumers evaluated vanilla ice cream containing 11, 13, 15, 17, or 19% sugar, by paired comparison-preference. Results showed the 3 higher levels were liked equally well but were preferred to a significant degree over the 11 and 13% sugar levels. Neither environmental temperature nor body size seemed to influence sweetness preferences. Males showed more decided preferences as a group than females. The two age groups of 16 to 25 and 25 to 50 showed more discrimination than younger or older consumers. People who consumed ice cream several times a week had more decided preferences than those who ate the food less frequently. By all methods of classification of the data, the sample containing 11% sucrose was least often preferred. (See page 679.)

Stabilization, enzymatic *Foods, beverages*

Glucose oxidase in the protection of foods and beverages. R. R. Barton, S. S. Rennert, and L. A. Underkofler.

A study of the characteristics of the glucose-oxidase-catalase enzyme system indicates that it is active over a wide pH range and is stable at relatively high temperatures. Its protective action of foods is dependent on the type of food with which it is used. When used with certain beverages it can protect color and flavor of bottled beverages. When used with canned beverages, it reduces iron pickup and is highly effective in reducing headspace oxygen. (See page 683.)

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

1957	
December 26–31	American Association for the Advancement of Science, Indianapolis, Indiana
1958	
January 11	High School Career Day, Sponsored by the Indiana Section of IFT, Rice Auditorium, Indianapolis, Indiana
January 27–30	Plant Maintenance and Engineering Show, International Amphitheater, Chicago, Illinois
February 25–26	Sixth Annual National Dairy Engineering Conference, Kellogg Center, Michigan State University, East Lansing, Michigan
March 2–6	Convention of National Association of Frozen Food Packers and Exposition, Conrad Hilton Hotel, Chicago
March 2–9	International Trade Fair of Packaging Machines, Confecionery Machines and Packaging Materials, Dusseldorf, Germany
March 6–8	Annual Meeting of the Refrigeration Research Foundation, Adolphus Hotel, Dallas, Texas
March 14–15	Annual Food Technology Symposium and Short Course, University of Missouri, Columbia, co-sponsored by the St. Louis and the Kansas City Sections of IFT
April 7–11	The American Association of Cereal Chemists, Netherland-Hilton Hotel, Cincinnati, Ohio
May 25–29	**Eighteenth Annual Meeting of the Institute of Food Technologists, Palmer House, Chicago, Illinois**
1959	
May 17–21	**Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania**
1960	
May 15–19	**Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, California**
1961	
May 7–11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17–20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Miami Beach, Florida**
June 10–13	First International Congress on Vacuum Techniques, Namur, Belgium
June 12–13	First National Convention, Canadian Institute of Food Technology, Windsor Hotel, Montreal. Theme: Canada's Food Industries

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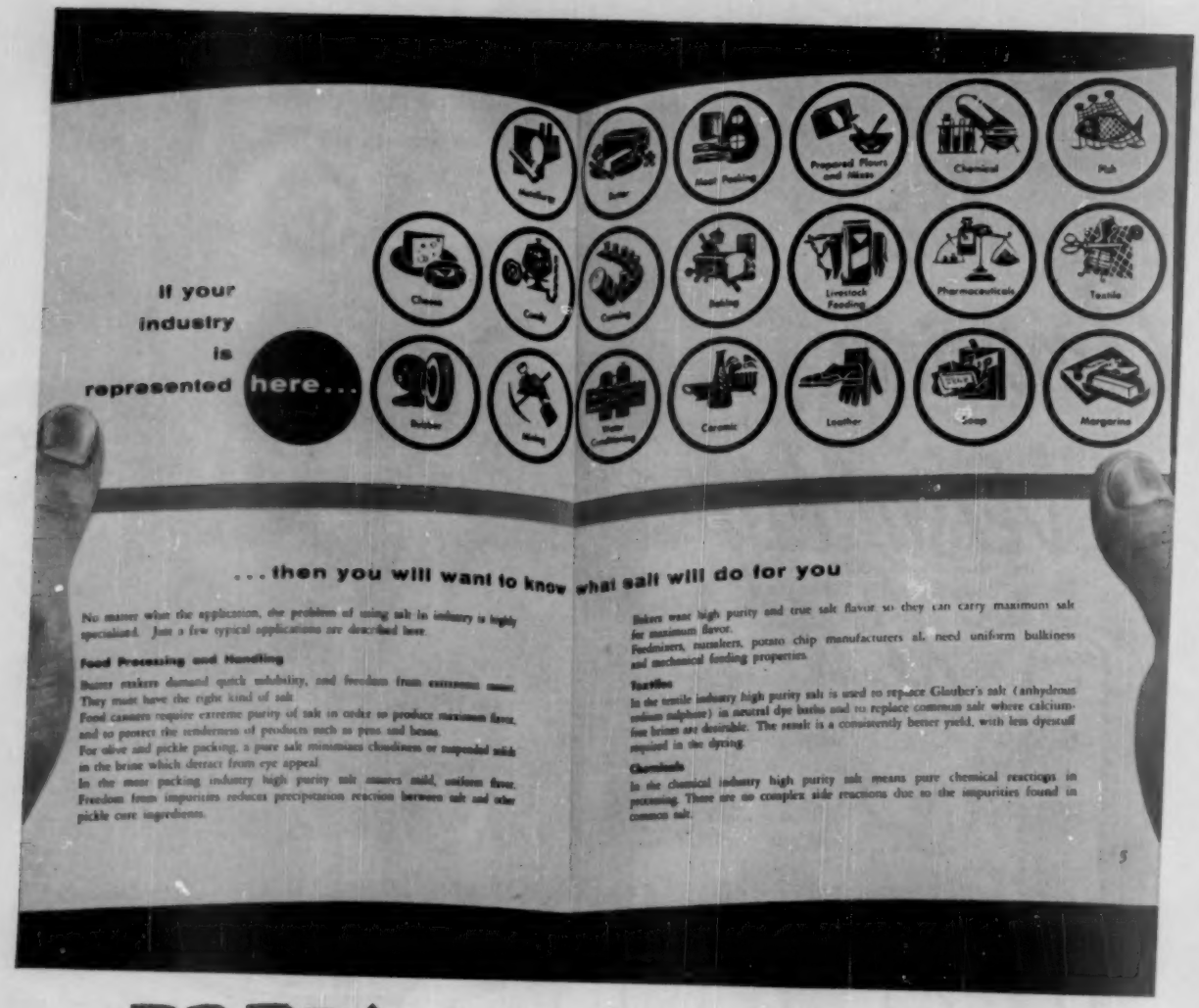
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5

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New Trends in Food and Our Changing Food Habits*

Geo. F. Garnatz
The Kroger Food Foundation,
Cincinnati, Ohio

FOOD HAS BEEN A MATTER of primary concern to man from the days of his nomadic existence, through the era when he settled down to follow agricultural pursuits to provide for his own requirements, up to the present highly industrialized period where, in the more advanced areas of the world at least, his food is made available to him by the relatively few specialists engaged in the production, processing and distribution of his food needs. Nevertheless, despite a mounting appreciation of the role of nutrition in the maintenance of well-being, the anomalous situation has developed wherein man accepts his food with a great measure of casualness. Admittedly, he enjoys the experience of eating. He finds congeniality in sharing the experience with others. He is not unresponsive to the esthetic qualities of the foods he eats. On the other hand, he takes for granted and is relatively lacking in his appreciation of what is done to bring food to him.

George F. Garnatz

He takes great pride in his ownership of the many mechanical devices to make living more comfortable and convenient, to provide him with entertainment and to make the wide outdoors his playground. With admiration and respect he concedes to those who build his automobile, television set, vacuum sweeper or automatic washer, the incorporation of skill, research knowledge, provision and ingenuity in these gadgets. He is little aware that these same attributes combine to bring his foods to him clean, sound, wholesome and nutritious, with their fresh qualities, flavor characteristics and eye-appealing properties substantially conserved. He little appreciates what has been involved to preserve foods for him, to provide variety independent of the seasons and to hedge against short supplies. He takes for granted the convenience of preparation and serving that is being built into more and more food products in order that they may fit into the pattern of modern living.

WE HAVE PUSHED BACK THE FRONTIERS OF FOOD KNOWLEDGE

From the days of Nicholas Appert, who established the principles of the canning process and the researches of Louis Pasteur which are basic to so many food processes, Food Technology and Food Engineering, through research, have been combining to push back the frontiers of knowledge and to make new applications so that foods of increasingly better quality and in greater array might be made available. These developments make a most interesting story. They stem from changes such as the industrialization of our nation, the transition from reliance on fresh foods to processed foods, the urbanization of our population, our desire for convenience and service features in our foods, our increasing population and our advancing knowledge of nutrition.

Just think; our population is increasing at the rate of seven thousand a day so that by 1978 it is estimated that the population of the United States will be two hundred and thirty-one million.

Let's dwell a bit on the theme of from whence we have come nutrition-wise. From 400 B.C. until 1830 we believed all foods contained, in common, but one element to sustain life.

In 1834, according to Dr. Fredrick J. Stare, Prout made the discovery that foods could be broken down into three nutrients—carbohydrates, protein, and fat.

During the Civil War the minerals came into the nutritional picture just ahead of the interest in the energy or caloric values of food which developed with the turn of the century.

Along about 1912 the vitamin era was inaugurated to be followed by greatly accelerated advances in our newer knowledge of nutrition so that today, we recognize fifty to sixty individual nutritional factors. Perhaps one or two examples will serve to illustrate the trend of application of our knowledge of nutrition.

Bread

Bread is such a basic food, it is appropriate that it be used as the first example. Just before the outbreak of World War II it became apparent that a significant segment of our relatively well-fed population was getting an insufficient supply of some of the B vitamins and the mineral iron. Our knowledge of nutrition not only enabled nutrition experts to appreciate this but permitted them to devise ways and means for applying corrective measures.

At just about the same time, our rapidly advancing knowledge concerning the vitamins led to the chemist making many of them in the laboratory. Manufacture

* In the preparation of this manuscript the author desires to acknowledge the use of material from the Agriculture Information *Bulletin No. 138*, U. S. Dept. of Agriculture; *Agriculture Handbook No. 56*, U. S. Dept. of Agriculture; *Food Engineering*, 25, (10) October, 1953; Food Marketing Changes (George S. Pillsbury); How Can Consumer Education Influence Marketing (Connie Foote); and *Technical Bulletin No. 963*, U. S. Dept. of Agriculture.

on a commercial scale soon followed, making pure vitamins available at an economical cost.

Thus was paved the way for nutritionists to conceive the device of enrichment whereby, through white flour, white bread and cornmeal there were added to the dietary, automatically and on a mass scale, significant amounts of thiamin, niacin and riboflavin (three of the B vitamins) plus the mineral iron. White flour, white bread and cornmeal were selected as the vehicles for enrichment because they are so widely and regularly consumed, they are economical and are essentially starchy foods which are more readily assimilated if thiamin intake is geared to them.

Now, after more than a decade of use, enrichment is recognized as an effective public health measure. The results of a large-scale study and test in Newfoundland and another with enriched rice in Bataan, point this out rather dramatically. Even in this country the reduced occurrence of pellagra and sub-clinical evidence of B vitamin deficiencies since the institution of enrichment is being credited to its contribution to better nutrition.

Enrichment, therefore, is considered the third milestone in the automatic and mass application of improved nutrition and takes its place with iodized salt, which protects against goiter, and vitamin D milk which has proven so effective in the prevention of rickets. Now come fluoridation of public water supplies, baby foods, geriatric foods and dietetic foods to assist the obese, the diabetic and those on sodium-free diets.

Meat

Similar technological progress is being made in the areas from which come our meat supplies. Here a sequence of events starting with breeding studies, progressing through feeding and management experiments, combined with advanced dressing techniques aided by time-saving steps, modern sanitation and modern refrigeration result in safe, high-quality, fresh meats. Streamlined modes of transportation and distribution, coupled with efficient cutting methods and prepackaging, bring to the consumer, products from which she can select what she wants, in the amounts she needs, at the price she is willing to pay.

Heretofore, the tenderness that comes with aging beef was not generally available. A means of tenderizing beef has been developed which yields a product of tenderness equivalent to aged beef and more tender than fresh beef as it comes to the consumer in the ordinary channels of distribution. The beef tenderized by the new method is merchandised competitively with unaged beef. The new process accelerates the natural enzymic process, usually accomplished by holding at a relatively low temperature for two to three weeks and entailing significant losses due to shrinkage and trimming. In forty-four hours the new method accomplishes the equivalent result in an environment maintained at 68° F. with high humidity and bacteriostatic conditions supplied by ultra-violet radiation of adequate intensity.

Fresh fruits and vegetables

Great progress has been made in the fields of transportation and refrigeration. This is very apparent in connection with the supply of fresh fruits and vegetables. The lettuce capitol is in California and carrots as well as other fresh vegetables from that state, Colorado, Florida, Texas and elsewhere, are commonplace. Fresh strawberries appear in February and continue in supply through the home-grown season. Fresh tomatoes and green beans no longer are confined to any season.

The application of refrigeration to these products begins right in the fields for it has been learned how advantageous it is in staving off deterioration, to remove the heat of the field as promptly as possible. The application of refrigeration extends all the way through to the point of retail sale. Experiments have shown clearly that refrigeration, coupled with an adequate level of humidity, for green goods, pays dividends in conservation of quality and losses from decay and trimming.

Canning

However sketchily one might trace the trends in food, it cannot be done without some mention of the canning industry. A few examples, however, must serve to illustrate. Unquestionably the severe heat treatment to which canned foods are subjected changes them so they differ from the original fresh product in flavor, texture and sometimes color. Consequently, the search here is for a safe process which, at the same time, will conserve fresh qualities. The obvious direction in which to probe is toward a reduction in the sterilizing time. The first step in that direction is the continuous pressure cooker which is now generally used for canning evaporated milk. It is not the complete answer however, and moreover, is limited in its application to products with a degree of fluidity which lends itself to ready heat penetration. An atmospheric version of the continuous cooker is also available for processing acid foods like peaches, pears and apricots.

More recently a new process for canning has been announced which calls for sterilizing the product by a high temperature-short time or "flash" sterilization step, followed by filling and sealing the product in sterilized cans and lids under aseptic conditions. This is a revolutionary and promising line of development. In all probability it will come into general use as specific problems in connection with individual items are solved and as equipment implementing and facilitating the process becomes available. It is said that the quality of products processed by the aseptic method are greatly superior to the comparable conventionally canned products.

Frozen foods

At times one labors under the illusion that frozen foods have long been available. Upon more reflective thinking, however, comes the realization that not too long ago they came into their own. Here is a relatively

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new industry which must be recognized as influencing the trend in food. In effect, the freezing process has obliterated the seasons. Applied to vegetables, fruits and berries, it brings to the consumer an array of products with their fresh qualities substantially conserved. It brings to the land-locked population, seafoods of a quality comparable to that heretofore obtainable only along the seacoasts. It provides products offering much in the way of convenience for preparation and serving. Increasingly there are appearing fully prepared foods or food combinations requiring merely and concurrently, defrosting and heating preliminary to serving. A partial list of such products includes meat pies, chicken and turkey pies, tuna pie, fruit pies and T. V. dinners.

The most spectacular development in this field has been frozen concentrated orange juice. It has set a pattern and has provided incentive for the development of other similar products and processes, achieving a comparable result. Already the other citrus products have been put up in this form, including lemonade. Frozen concentrated grape juice and apple juice are also available and, in the offing, may be frozen concentrated milk, pineapple juice and tomato juice. That the consumer appreciates the quality and convenience of such products is testified to by the phenomenal acceptance she has accorded frozen concentrated orange juice and the significant effect it has had on the increased consumption of citrus fruits in the United States.

Fats and oils

The fats and oils have not been without impact on the trend in food. There was a time when lard was the traditional cooking fat. Then came the hydrogenated vegetable oils and in large measure, displaced lard in the home. Later came the incorporation of small amounts of mono- and di-glycerides in the hydrogenated vegetable oils which so enhanced their cake-making properties that today, this type fat is virtually a standard ingredient in quick-mix cake recipes. More recently lard is getting back in the picture in the form of the bland type which has been subjected to some refining, has had texture bodied with some hydrogenated lard, has been stabilized with an approved anti-oxidant and perhaps contains some mono- and di-glyceride to qualify it as a shortener for cake making.

One cannot leave this area without some mention of oleomargarine. Steady progress has been made in the improvement of the quality of this product, texture- and flavor-wise. Additives such as lecithin and mono- and di-glycerides prevent water leakage and splattering on frying and provide emulsifying capacity for cake making. During the war, oleomargarine was sampled extensively by the consumer and liked. Post-war, now that it is permissible to add color and vitamin A is added in a significant amount, it has won even greater acceptance by the consumer. The result is that currently about as much oleomargarine is consumed as is butter.

Prepared mixes

Prepared mixes have increased more than eight-fold since 1946, simply because their quality has been so good that Mrs. Consumer has capitulated to their convenience appeal. Instant coffee is still growing in popularity. Instant pudding mixes have been introduced and are making steady progress. Already orange juice and grapefruit juice crystals, as well as tomato solids, are becoming available which can be reconstituted by merely adding water in proper amount to a given quantity of the dehydrated material. These examples call to mind that many processed foods embody features of service and convenience so that today the homemaker spends only about one hour and thirty-six minutes in the kitchen to prepare a day's food for a family of four. About thirty years ago, five and one-half hours were required to accomplish the same end.

WHAT HAS BEEN THE EFFECT?

What has been the effect of such developments on our food habits? The Bureau of Agricultural Economics index reveals that per capita food consumption in 1952 compared to the pre-war years (1935–39) is twelve per cent greater. Although the average person in the United States is eating a slightly larger amount of food, he is still eating about the same number of calories. The current trend is toward fewer calories which is desirable since obesity is one of the major problems in the field of human nutrition. The calories per person per day in the national food supply have declined from an average of 3450 to 3250.

We now consume more meats, poultry, eggs, milk, cheese, ice cream, vegetables and fruits. We are eating fewer potatoes and less grain products. There has been a slight increase in the consumption of fats. Since our total calorie intake is down, this means that the number of calories derived from fats has increased over the years from 32 to 40 per cent; that from protein has remained constant at eleven per cent so that the carbohydrates (starch and sugar) account for correspondingly less, namely, 49 per cent. Compared to 1910, we are now consuming approximately:

50 per cent more fruits and vegetables

25 per cent more dairy products

30 per cent more eggs

10 per cent more meats, poultry and fish

30 per cent *less* grain products

40 per cent *less* potatoes

Our diet is better now compared to 25–30 years ago because it contains more of these essential nutrients and desirable foods as indicated by the following percentage increases.

Calcium (mineral)	15%
Iron (mineral)	15%
Vitamins A and C	5%

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Thiamin and Niacin (B vitamins)	20%
Riboflavin (a B vitamin)	25%
Proteins	5% (scant)
Eggs	36%
Meats	18%
Citrus and tomatoes	23%
Leafy and green vegetables	11%

To illustrate this point further, the annual consumption per person of the following foods for 1954, compared to thirty years ago, is:

1924		*1954*
20 lbs.	Oranges	58 lbs.
14 lbs.	Chicken	23 lbs.
318	Eggs	405
59 lbs.	Beef	72 lbs.
27 lbs.	Tomatoes	53 lbs.
9 lbs.	Ice Cream	17 lbs.

As well fed as is the population of the United States, there is no room for a feeling of smugness on this score. There is still opportunity for improvement. The Bureaus of Human Nutrition and Home Economics and Agricultural Economics point out that if all the diets in the population that are below standard were to be brought up to moderate-cost, adequate diets, this country would consume,

36% *more* milk
31% *more* green and yellow vegetables
30% *more* citrus
14% *more* other fruits and vegetables
18% *more* meats
1% *more* eggs
3% *more* grain products
2% *more* potatoes

Here is plenty of incentive to continue the upward trend in food quality and variety. Here is ample incentive to raise the nutritional level of the population of the United States through further research and by extending the fruit of such research to the point of application.

WHERE DOES THE STORY END?

Where does this story end? Well, it will never end. In the fields of food production, processing and distribution, there are still so many things to learn, conditions are so fast moving and competitive that increasingly great sums are being invested in research and product development so that technical advances may continue to come at an ever increasing pace. The trend is in the direction of streamlining, making continuous and automating methods of food processing and preservation.

Bacon can now be cured in one day. In addition to controlling the distribution of salt in the bacon, this process brings the sliced and packaged product to the point of consumption so rapidly that sound, fresh flavor is conserved for the consumer's enjoyment.

Frozen meats are through the first stage of experimental merchandising. The results have been sufficiently encouraging to warrant extending their availability. They are a logical follow-up to pre-packaged meats and in addition to reducing the perishability of meats will permit advantage to be taken of the efficiencies and economies which reside in centralizing the cutting and packaging operation at the packer level.

The work of Dr. F. E. Deatherage and his coworkers at Ohio State University is pioneering the application of antibiotics for the preservation of foods. Already they have hit upon the device of infusing beef carcasses with a dilute solution of an antibiotic with the result that the flesh will keep without spoilage and without refrigeration for three or four days. One variant of the idea has been introduced recently for commercial application. It consists of combining a very small amount of antibiotic in the final ice-water chill in the dressing of poultry. Subsequently packaged and held under refrigeration, poultry so treated enjoys a greatly extended fresh life.

The day is at hand when bread can be made by a

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continuous process. The yeast and some of the sugar, dissolved in water, are fermented under controlled conditions. The concentration of this "brew" is adjusted so that a selected aliquot proportioned to the flour used, yields a dough of the desired consistency. This "brew", along with flour, salt, milk, fat, additional sugar and such other ingredients as may be desired is proportioned into a screw-type pre-mixer which forms a dough and from whence the dough proceeds to a continuous "developer" to acquire the desired degree of plasticity. As the dough leaves the developer it is automatically scaled off and shaped into loaf units. A pan conveyor, synchronized with the discharge of the dough developer, delivers pans to a point where the formed loaf units automatically drop into the pans. The rising of the dough in the pans takes place in an automatic continuous proofer. The raised dough is then automatically fed into an oven of the continuous type, emerges, is mechanically de-panned, proceeds to a continuous cooler after which it proceeds to the slicing and wrapping operation.

There is only one known way to inhibit the staling of baked products and that is to freeze them and hold them until used at a temperature of 0° F. Frozen baked products have even now made their appearance and the homemaker is learning that she can hold packaged baked products in her home freezer to conserve their freshness and palatability until the time she is ready to use them. Economic trends, the growing tendency to shop for food but once a week, the ability to plan production and to take baked products out of the perishable category, are factors which will encourage the more general use of freezing in conjunction with baked products as time goes on.

Initiating a bread freezing experiment in a USDA regional laboratory

It is said we are living in the Atomic Age. Our rapidly developing knowledge of nuclear physics was first applied to the waging of war. Then it became recognized as a valuable tool in the conduct of medical research. Currently it is receiving a great deal of attention as a means of providing peace-time power and it is even being studied as a probable new method for the preservation of food!

Cold sterilization

Ever since the discovery of X-rays by Roentgen it has been known that radiant energy could sterilize, but up until now, the forms available have been inefficient and expensive. To the initiated, therefore, there is nothing new about the idea of radiation processing of food. But, nevertheless, the use of radioactivity in this application has great novelty appeal. It is intriguing and is full of promise since it is a means of preserving without subjecting the product to an appreciable degree of heat.

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As a matter of fact, it has been established that foods can be sterilized with gamma rays as they emanate from radioactive Cobalt 60 for example, or with beta rays or high velocity electrons as developed by machines designed for the purpose. Let me hasten to add that any radioactive source, including neutrons, would not be used since they would not lend themselves to a process that would be safe. Let me also hasten to say that no radiation process for foods will be applied until it has been established that foods so treated are safe for people to eat.

Since radiation processing sterilizes without appreciably raising the temperature of the food being treated, it holds the promise of providing foods that will keep in packaged form indefinitely, without benefit of refrigeration or freezing, and with their fresh qualities of color and taste unimpaired. Up to now, however, the radiation dosages required for complete sterilization, which, however, are not sufficient to inactivate enzymes, do bring about some undesirable changes. A great deal of research needs to be done before radiation sterilization is realized but the outlook is optimistic. It is already known that some of these undesirable changes can be reduced by irradiating at low temperature and in the presence of certain added substances. Many questions of an economic nature and others related to the engineering and production phases remain to be worked out. However, research in these fields is going forward in about forty-seven organizations in the United States alone, so that under such intensive scrutiny it is felt that radiation sterilization may be but ten or more years away.

It has also been learned that lighter radiation dosages will accomplish a degree of surface sterilization such that beneficial effects will be realized. Grain can be freed from insect infestation. Potatoes and onions are affected so that they will not sprout. Trichina in pork can be inactivated. Provided it be held under refrigeration, packaged meat has its edible life extended five- to ten-fold and for some packaged produce items spoilage can be reduced and edible life can be extended. These applications are somewhat nearer at hand. Some say they are not more than one to two years away. Such applications, however, will not be made until the safety of the foods have been established through adequate feeding tests, cost factors have been worked out, engineering features have been designed and production methods have been developed. Nevertheless, radiation processed foods are destined to find a place in the food picture of the future.

ALL OUR RESOURCES ARE BEING MARSHALLED

Now, as never before, the value of scientific research is appreciated so that all of our resources for discovering new knowledge in the fields of food production, processing, distribution and nutrition, are being marshalled and augmented for the job ahead. Thus will the attributes of human knowledge, skill, provision and ingenuity be brought to bear on these problems so that the quality of food may be improved continuously and so that people may not only be well-fed, but properly nourished.

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Agricultural Research Institute Holds Sixth Annual Meeting

October 14, 15, in Washington, D. C.

Frank L. Gunderson

Liaison Representative from the Institute of Food Technologists

MANY FOOD PROCESSING and other Class A (dues paying) agricultural industry organizations were represented at the Sixth Annual Meeting of the Agricultural Research Institute in Washington, D. C., October 14–15, 1957. The ARI operates in close coordination with the Agricultural Board of the National Academy of Sciences–National Research Council. Walter C. Dutton of The Dow Chemical Co. completed his second term as President of ARI and was succeeded for the new year by C. L. Rumberger of H. J. Heinz Co., Pittsburgh. New Vice President of the ARI is Dr. Burt Johnson of the National Cotton Council, and the Secretary is Dr. C. H. Mahoney of Merck & Co., Inc., Rahway. Messrs. Rumberger and Mahoney are well-known to many members of the IFT.

The final paragraph from the formally stated purposes of the ARI bears reiteration: "The Agricultural Research Institute was established in 1951 as a means of organizing the scientific talents of industry, public agencies, scientific societies, and private institutions in support of the Agricultural Board, and to provide a forum for unrestricted discussion of common problems."

The ARI brings together representatives of industrial organizations, agricultural experiment stations, and academic groups in agricultural research activities.

Wheeler McMillen and several associates from the President's recent Commission to study better industrial utilization research, reviewed that project which will probably again be in the limelight in the form of the Capehart and other bills in the second session of the 85th Congress. Essentially, the recommendation is that funds for utilization research to help cope with the surplus agricultural products be increased about 3-fold over the present level of sixteen million dollars.

Another important part of the program related to present and future basic research in animal sciences.

A third portion of the program reviewed the activities of the Agricultural Board for the benefit of the ARI members. One very interesting part here related to agricultural meteorology and climatology and pinpointed some of the weaknesses in our present knowledge and activities in those fields.

The ARI now has approximately 75 members, who pay dues of $300.00 each per year. This money helps to suppjort the activities of the Agricultural Board and its sub-committes and to maintain continuity of activity through Dr. LeRoy Voris, Executive Secretary, ARI, at 2101 Constitution Ave., N.W., Washington 25, D. C. Dr. Voris advises he will be glad to provide information to those who wish to make general or more specific inquiry about ARI and would welcome additional organizations into membership. As a personal remark, I am deeply impressed with the opportunity this annual meeting—usually held about mid-October—affords for the constructive exchange of ideas between industry, university, experiment station and government people all interested in one way or another in agricultural research.

Last Call for Babcock-Hart Award Nominations

This is the second and last reminder that the rules and regulations governing the Babcock-Hart Award provide opportunity for members of the Institute to nominate candidates for this Award. Nominations should be in the form of a two page, single spaced, typewritten letter giving a biographical sketch and qualifications of the individual recommended. Such letters should be sent to G. F. Garnatz, Chairman, Babcock-Hart Award Jury, The Kroger Food Foundation, 1212 State Avenue, Cincinnati 4, Ohio. They must be received by January 1st, 1958. Do not delay! If you have someone in mind who, in your opinion, is eligible for this Award, send in your nomination to the Chairman of the Jury now!

Consumer Acceptance of Foods

Symposium and Short Course to Be Held at the University of Missouri in March

AN IFT SECTIONAL EVENT of increasing importance, the Sixth Annual Food Technology Symposium and Short Course will be held on the Campus of the University of Missouri, Friday and Saturday March 14th and 15th 1958. Dr. Emil M. Mrak, President of the Institute of Food Technologists, will be the banquet speaker.

This Symposium and Short Course has been jointly sponsored by the St. Louis Section of IFT and by the College of Agriculture of the University of Missouri, since its inception in March of 1953. Now in 1958 the Kansas City Section of IFT is joining in and co-sponsoring the meeting.

The overall title of the program is "Consumer Acceptance of Foods — Problems — Methods — Experiences."

The tentative program is as follows:

FRIDAY, MARCH 14, 1958

Student Union Bldg., University of Missouri, Columbia

8:30 Registration

9:30 Welcome Address

9:45 Factors and Problems Related to Consumer Acceptance

10:15 Psychological Aspects of Consumer Acceptance

10:45 Coffee Break

11:00 Economic Aspects of Consumer Acceptance

11:30 Consumer Acceptance from the Housewife's Viewpoint

12:00 Open Discussion

12:30 Luncheon

1:30 Methods of Determining Consumer Acceptability

2:00 Interpretation and Application of Methods

2:30 Open Discussion

3:15 Tour (New Medical Center)

5:00 Social Hour—Daniel Boone Hotel

7:00 Banquet—Memorial Student Union. Address by Dr. Emil M. Mrak, President, IFT

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SATURDAY, MARCH 15, 1958

Memorial Student Union Bldg.

8:30 Registration

9:30 Session on "Experiences in Meeting Consumer Acceptance"

"Using Consumer Acceptability Studies in Product Design"

"Marketing and Consumer Acceptance of Food Products"

"Product Modification to Assure Consumer Acceptance"

11:30 Summation by Moderator of the Session

12:15 Luncheon — Grill Room — Memorial Student Union.

Again this year the program will be in the form of Panel presentations followed by open discussion periods. An excellent group of speakers are being contacted and complete listing of all speakers with their exact paper titles will be announced later.

Registration again is only $5.00 and includes admission to all Sessions, the Social Hour, the Banquet and Dr. Mrak's address. Extra banquet tickets are available for registrants who wish to bring guests to the banquet and evening program.

Inquiries may be directed to:

DR. O. J. KAHLENBERG, Chairman
Food Technology Short Course
No. 4, New Agriculture Building
University of Missouri
Columbia, Missouri

Roster of Papers for 1958 Annual Meeting of IFT

To Be Completed by January 1, 1958

The first major task of putting on an annual meeting is proceeding toward a conclusion. As announced in the August and September issue of FOOD TECHNOLOGY, titles and abstracts of the technical papers must be in by January 1, 1958. Within two weeks thereafter the final program for the technical sessions will have been drafted. It is necessary to remind authors of papers that January 1, 1958, is a firm deadline. The innumerable details involved in working out the organization of sessions, scheduling the sessions to avoid major conflicts between subject matters, and assuring completeness of titles, authorship and abstracts do not allow for late entries.

Technical Sessions

A recapitulation of the technical sessions and their respective chairmen follows:

1. **Radiation Preservation of Foods.** DR. H. W. SCHULTZ, Oregon State College, Food Technology Department, Corvallis, Oregon

2. **Canning.** MR. W. E. PEARCE, American Can Company, Research & Technical Department, Maywood, Illinois

3. **Frozen Foods.** MR. G. V. HALLMAN, Campbell Soup Company, Research & Development, Camden, New Jersey

4. **Meat, Fish and Poultry.** MR. C. K. WIESMAN, Armour & Company, Research Division, U. S. Yards, Chicago 9, Illinois

5. **Cereal and Bakery Products.** DR. P. E. RAMSTAD, Technical Director, Products Control Department, General Mills, Inc., Minneapolis, Minnesota

6. **Citrus Products.** MR. H. W. TRUMM, Libby McNeill & Libby, Ocala, Florida

7. **Dehydration.** MR. R. W. KUENEMAN, J. R. Simplot Company, Caldwell, Idaho

8. **Packaging.** MR. L. J. HAYHURST, Kraft Foods Company, Research Laboratories, 923 Waukegan Road, Glenview, Illinois

9. **Food Engineering.** MR. G. A. CRAPPLE, Wilson & Company, Inc., Research & Technical Division, 4100 S. Ashland Avenue, Chicago, Illinois

10. **Instrumentation.** MR. J. H. BOCK, Continental Can Company, Process Engineering, 1350 W. 76th Street, Chicago 39, Illinois

11. **Prepared Foods for Military Use.** DR. R. G. TISCHER, Quartermaster Food and Container

How to diet for a figure—

Dessert plan
weight w

to diet for a figure—No. 1 of a series

attle plan for
weight watch

By Ronald G. Ginsberg

The
Dramatic
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Diet

....in a pre-sold market

Only diet products are getting this kind of editorial pre-selling:

How to diet for a figure—No. 3 of a

Dessert plan for weight watchers

No easier time than now to trim down that waistline! Mother Nature's on your side with an abundance of summer-ripe fruits. Markets and roadside stands offer this bounty at a bargain.

Food manufacturers are ready to help—canned fruits, low-calorie pastries, reducers' fruits—can sweeten re- calorie-

Fruits—your calorie pals

You couldn't ask for more luscious eating than you see across the page. So revel in the fruits of the season. Choose a variety—serve them in their natural glory, in combinations, and in gelatin or frozen desserts.

Health bonus. Fruits help dieters get their quota of vitamins and minerals. Count on oranges, grapefruit, lemon and lime juice, cantaloupe, honeydew, for vitamin C

ON-OFF DIETING can be dangerous!

Slim do wi

How to diet for a figure—No. 2 of a series

Protein plan for weight watchers

So pounds are your problem. Likely your doctor has suggested a high-protein reducing diet—one that supplies plenty of vitamins and minerals, too, but low on calories.

Here's why a safe-and-sure reducing diet is loaded with protein foods: Protein helps protect against loss of muscle tissue while the

Meat's your

THE COMM

to diet for a figure—No. 1 of a series

attle plan for weight watchers

By Ronald G. Cooley

S want to lose weight. One of the big hazards —eat away from home. Perhaps your job calls for —more dinners and banquets. Or —diet parties—

RUTH WEST ...ber of the best sellin... ...p Dieting! Don't Lose...

The Dramatic POUND-A-DAY Diet

LIKE to April Fool about a pound a day off your frame... the next few days! If you are in good health, here's a s... food combination that works like wildfire, due largely t...

The plump and the padded

BATHING SUITS and shorts are sinister summer traps for figures that bulge where we wish they wouldn't. Other traps lie in wait for plump and padded folk who want to lose fat without going on a reducing diet, or who think no diet can work *for them* because they hardly eat enough to keep a bird alive. Here are a few inspiring facts about fat taken from the new *Better Homes & Gardens* Diet Book. Just look them over, and they may lead to some sprightly changes in your weigh of life.

WARNING TO DIETERS:

Fad Reducing Tricks Can Ruin

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Only Sucaryl-sweetened diet products get this kind of advertising pre-selling:

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It represents by all odds the biggest, most colorful campaign ever put behind any calorie-free sweetener.

The fact that Sucaryl outsells all other non-caloric sweetener brands combined is, no doubt, partly due to this advertising. The fact that Sucaryl sweetens "so you can't taste the difference" also shares credit for this overwhelming consumer preference . . . a preference that carries over to diet foods and beverages sweetened with Sucaryl.

For complete information about Sucaryl and its usefulness to you, we suggest you write for a copy of our booklet, "Making the Most of the Dietetic Market with Sucaryl". Please address Chemical Sales Division, Abbott Laboratories, North Chicago, Illinois. On request, we will also send you a sufficient supply of Sucaryl for your own test purposes.

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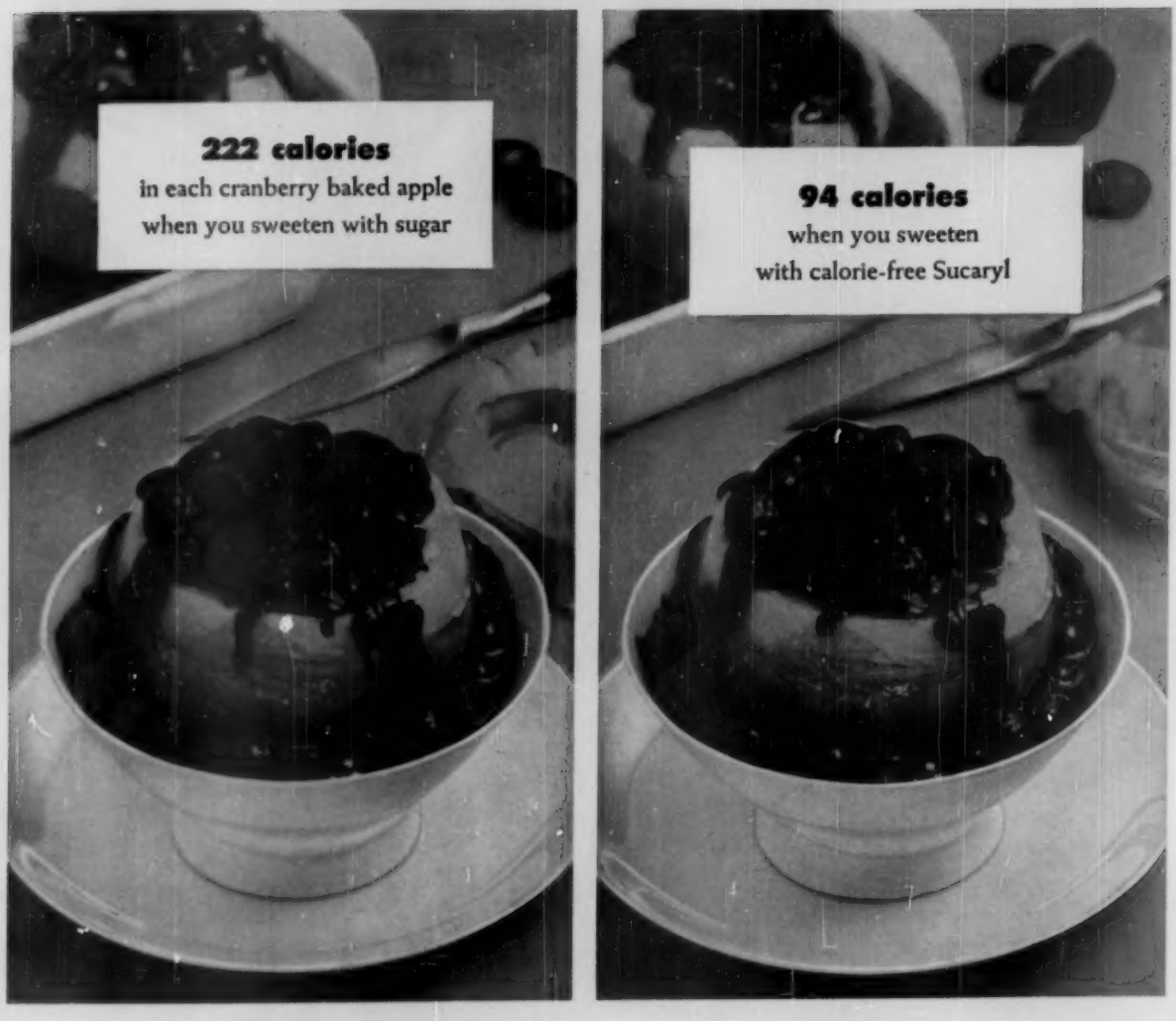
on your labels, in your advertising and in your store displays

Here's Sucaryl's current "ad-of-the-month"



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and you can't taste the difference

WEIGHT WATCHERS' CRANBERRY BAKED APPLES

6 medium red cooking apples
2 cups cranberries
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Set oven at 450°F. Core apples and pare one-third of the way down. Place in a shallow baking dish. Combine the remaining ingredients in a small saucepan and cook until berries pop. Fill center of each apple with a tablespoon of the cooked cranberries; pour remainder over apples. Cover with aluminum foil and bake for 20 minutes. Remove foil and bake 5 to 10 minutes longer. Makes 6 servings.

Sucaryl makes it easier for you to watch your weight . . . by giving you wholly natural sweetness without bitter aftertaste, without one single calorie.

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Institute, 1849 W. Pershing Road, Chicago 9, Illinois

12. **General Research Papers.** DR. C. O. CHICHESTER, University of California, Food Technology Department, Davis, California

Masters and Doctors in Food Technology and Related Subjects—1957

A roster of graduates in food technology, science, and related subjects has been supplied by the University of Missouri at Columbia. The graduates listed are from various departments of the College of Agriculture.

UNIVERSITY OF MISSOURI, COLUMBIA

Name	Degree	Title of Thesis
Bevirt, Joseph L.	M.S.	The Determination of Lindane Residues with Special Emphasis on the Schechter-Hornstein Colorimetric Method
Hedrick, Harold B.	Ph.D.	The Effect of Antemortem Stress on Postmortem Beef Carcass Characteristics
Holman, Marilyn A.	M.S.	An Experimental Study for Adapting Soft Wheat Flour to Yeast Bread Formulae
Hurley, William C.	M.S.	The Effect of Low and High Levels of Inorganic Salt Concentrations on the Flavor and Water Absorption of Fowl and Broilers
Huskey, Glen E.	M.S.	The Effect of Temperature on Keeping Quality of Milk in Market Channels
Mullins, Auttis M.	Ph.D.	The Effect of a Hot Curing Technique and Various Additives on Color Development, Color Stability and Organoleptic Characteristics of Cured Hams
Zobrisky, Steve E.	Ph.D.	Physical Composition of Swine During Growth and Fattening

New IFT Award

Call for Nominations

A new award to be administered by the IFT is the INSTITUTE OF AMERICAN POULTRY INDUSTRIES AWARD.

The Award consists of $1,000 and an engrossed plaque.

The purpose of the award is to stimulate research in the field of poultry and egg processing and marketing. To qualify a candidate, the research should be such that it reflects increased consumption of poultry and egg products.

NOMINATIONS

Nominations may be made by any member of IFT or any Regional Section of the Institute and by any member of the Institute of American Poultry Industries. Nominations shall be in letter form giving a biographical sketch and indicating the contributions that qualify the nominee for the award and shall be limited to two, single-spaced, typewritten sheets. The nominee must be a person under 39 years of age on December 31, 1958.

Send nominations to:

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IFT News

W. NEW YORK

The Section held its Annual Fall Meeting at the Moose Club, Batavia, N. Y., on November 17. The program consisted of an afternoon technical session at which four papers were given and a dinner meeting which was addressed by National IFT President Dr. Emil Mrak who is Head of the Department of Food Technology, University of California, Davis, Calif. The papers given at the afternoon meeting were as follows:

"Uniform Cost Accounting as Related to the Food Industry," by Mr. Gale Brown of Touche, Nive, Bailey and Smart, Rochester, N. Y.

"Packaging Trends in the Food Industry," by Mr. Howard D. Baker, Assistant to Director of Customer Research, Continental Can Co. Inc., Chicago, Ill.

"An Entomological Contribution to Food Technology," by Dr. A. C. Davis, New York State Agricultural Experiment Station, Geneva, N. Y.

"Radiation Sterilization of Foods," by Dr. Arthur W. Phillips, Syracuse University, Syracuse, N. Y.

INDIANA

Again this year the Indiana Section's High School Career Day committee has a program which will be of interest to potential food technologists and members alike.

The following speakers will address the students:

Dr. Gale R. Ammerman—Food Technologist, Purdue University.

Mr. Frank K. Lawler—Editor, *Food Engineering.*

Dr. Martin S. Peterson—Quartermaster Food and Container Institute, and Editor, *Food Technology.*

Miss Judy Ahring—Indiana University student and co-winner of the "Food Technology as a Career" essay contest held in conjunction with the first Career Day program.

The meeting will be held on January 11, 1958, at Rice Auditorium, Indiana State Board of Health Building, 1330 West Michigan Street, Indianapolis, Indiana. Registration of students, counselors, and members will begin at 9:00 A.M. The program, which includes the speakers and selected movies of food processing operations, will begin at 10:00 A.M.

Representative of Mid West Universities will again be present to counsel with interested students on the programs offered by their respective universities. All universities that have food technology curriculum are welcome. Universities wishing to have counselors present should contact Mr. Seb Davin, 5231 Boulevard Place, Indianapolis, Indiana.

Members of all sections are always welcome to the Indiana Section functions, but we wish to extend a special invitation to all members of IFT to attend this meeting.

Remember the day—January 11! Plan to attend and bring at least one high school student.

September Meeting

Two hundred and five members and guests of the Indiana and Chicago Sections gathered at Purdue University for the September meeting. Tours of Horticulture, Home Economics, Poultry, and Biology Departments were enjoyed by the group.

On September 28, the General Foods Fellowship Award was presented to Mr. John V. Spencer (third from left), Purdue University graduate student, by Dr. Aksel G. Olsen (second from left), vice president, General Foods, and president-elect of IFT. Dr. Lee Truman (far left) and Mr. Seb Davin (far right), chairman-elect and chairman, respectively, of the Indiana Section, participated in the ceremonies.

Dr. Aksel G. Olsen, president-elect of the national IFT gave a short address on food research, and presented the General Foods Fellowship to Mr. John V. Spencer, a graduate student in the Poultry Department at Purdue.

A barbecued chicken dinner was served at noon, and the members adjourned to Ross-Ade Stadium for the football game between Notre Dame and Purdue.

—*William J. Klinker*

NEW YORK

The New York Section held its first meeting of the 1957–58 season at its regular meeting place, the Brass Rail Restaurant at 43rd Street, on Wednesday, October 16. Dr. Siegfried S. Lichtblau of the College of the City of New York Department of Chemical Engineering spoke on "A Survey of European Research and Educational Facilities for the Food Industry." This personal report in words and slides told how European countries are training and using food technologists. The survey showed that the facilities and programs available in European countries are estab-

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lished to fill a broad range of needs for technologists at various levels, from apprentices to graduates in industry, government, and the academic world. Dr. Lichtblau's slides showed views of impressive research facilities and institutions as well as outstanding laboratories and researchers. Mimeographed outline summaries of the facilities, institutions, and programs in food technology and food research were available to those attending the meeting.

—Alan W. Katzenstein

KANSAS CITY

Our first season as a new section has gotten off to a good start. At our first meeting on September 19, Mr. A. C. Keith, Director of Laboratories at Seymour Foods, Inc., in Topeka, presented a film and discussion on egg solids. Using a similar treatment, Mr. Orville Anderson, Production Manager at Seymour's, described the newly developed machines which his company uses for breaking eggs and separating the yolks and whites from the shells. Dried eggs have come a long way in both quality and acceptance from the product so many of us knew in World War II. Aside from their obvious advantages in speed and labor saving also, the new breakers permit an increased level of sanitation. The operator, whose former job was that of hand breaking, now works simply as an inspector, constantly on the lookout for various defects in the eggs.

The speaker at the second meeting on October 17, was Dr. Max Milner, Professor of Cereal Chemistry at Kansas State College, who discussed the effect of the irradiation of wheat on the flour produced from it. The fungi which are largely responsible for heating in stored grain are destroyed by radiation at the level of 625,000 R.E.P. Such massive dosages have a markedly detrimental effect on several of the colloidal properties of the flour which contribute to good bread baking.

The officers of the Kansas City Section for the 1957–1958 season are:

Chairman—Dr. B. W. Beadle
Chairman-elect—Mr. R. H. Maxwell
Secretary—Dr. H. E. Newlin
Treasurer—Mr. J. E. Lawler
Councilor—Mr. J. M. Gorman

Food Technology Short Course

This two-day Food Technology meeting will be held again for the sixth time at the University of Missouri on March 14 and 15, 1958. The meeting is jointly sponsored by the St. Louis Section, the University of Missouri and the Kansas City Section. The subject this spring will be "Consumer Acceptance of Foods—Problems, Methods, and Experience," three half-day sessions being devoted to the three sub-topics in the order named.

A total of ten papers will be presented by representatives of Industrial and University Research. What obstacles must a new food product overcome; to what extent can its success be anticipated; and what stories of success and failure lie behind some of the recent major attempts at development? These will be the topics to be considered at the meeting.

TEXAS

The Texas IFT Section held its annual fall meeting at Texas A. and M. College, College Station, on October 12. The group met in the new Dairy-Biochemistry building to hear an illustrated talk on meat processing throughout the world by Dr. F. E. Deatherage, Head of the Department of Biochemistry, Ohio State University. A description of the Food Technology work and organization at the University of California was given by Dr. Mrak, Head of the Food Technology Department there and National President of IFT. After the talks a tour of the new facilities in the Dairy-Biochemistry building was held followed by a buffet dinner. The group then adjourned to attend the A. and M.—University of Houston football game.

Among those attending the Texas Section IFT meeting were l. to r. Dr. and Mrs. R. W. Lewis of Prairie View A. and M. College, Dr. E. Mrak, National IFT President, Mr. R. Lay, President Texas Section IFT, Dr. F. E. Deatherage, Head, Department of Biochemistry, Ohio State University and Dr. O. D. Butler, Head, Department of Animal Science, Texas A. and M. College.

—George J. Mountney

CHICAGO

The November meeting of the Section was held on Monday, November 11, 1957, at the Midland Hotel on Adams and Wells Street. A symposium on "The Food Technologists" was the feature of the day. The symposium began at 3:00 p.m. and after dinner at 6:00 p.m. the symposium was resumed.

The papers included:

1. "What Management Expects From Its Technical Staff" by William U. Hudson, V. P., Gerber Products Co., Oakland, Calif.
2. "What The Technologist Expects From Management" by Dr. Roy E. Morse, Prof. of Food Technology, Rutgers University.
3. "What The Consumer Expects From the Food Technologist" by Mrs. Elaine C. Norden, Director of Consumer Service Dept., Campbell-Mithun Advertising Inc., Chicago.
4. "What Sales and Marketing People Expect From Food Technologists" by George Anderson, Dudley-Anderson-Yutzy, New York.

The meeting was an outstanding success.

Literature

BOOKS

DAIRY BACTERIOLOGY. 4th Edition, 1957. By Bernard W. Hammer, and Frederick J. Babel. John Wiley & Sons, Inc., New York, 614 pp.

The fourth edition of this widely used college text and reference book has been revised and enlarged to include recent advances relating to dairy bacteriology. New chapters have been added which discuss Bacteriology of Milk Production; Milk Plant Operation; Washing, Bactericidal and Preserving Reagents; and Freezing Milk and Cream. Substantial increases in coverage have been incorporated into the chapters on Bacteriology of Lactic Cultures; Bacteriology of Cheeses; Bacteriology of Fermented Milk Preparations; and Milk Enzymes. Among recent developments in dairy science, good discussions are given of the latest information on farm milk tanks and pipe line milkers and on psychrophilic bacteria in relation to recent practices in milk storage. A detailed consideration of bacteriophage and antibiotics from the standpoint of dairy bacteriology and current information on lipase and phosphatase are other items that were well covered. The chapters not mentioned specifically above have been satisfactorily revised by the addition of new material and by deleting topics which have little current interest or application. The first ten chapters cover material of value to both the producer of milk and the manufacturer of dairy products. The last ten chapters are concerned primarily with the bacteriology of manufactured products. Pertinent references to the material discussed in the text are listed in each chapter; in some chapters the number of citations is extensive.

R. O. WAGENAAR
Minneapolis, Minnesota

ESSENTIALS OF NUTRITION. 4th edition, 1957. By Henry C. Sherman and Caroline Sherman Lanford. The Macmillan Company, New York.

This beautiful-written book, appearing now in its fourth edition, is an old acquaintance of nutrition-conscious persons. The information presented summarizes and interprets scientific advances in the dynamic field of nutrition research.

The expressed purpose of the book is to help make the science of nutrition ever more effective in the service of health and efficiency. The opening chapter deals with the contribution of nutrition to improvement of life. In the main body of the text are discussed the energy aspects of nutrition, the proteins and their amino acids, the mineral elements, and the vitamins. The relation of these to human health is emphasized. Nutritional characteristics of food commodities, food costs in relation to food values and nutrition policy are the concluding chapters. The information is presented very concisely. Included in the Appendix are tables of composition and nutritive values of foods, a brief summary of fatty acids and their occurrence, a table of digestive enzymes and their functions, a table of recommended dietary allowances, and a glossary of terms used in connection with the science of nutrition.

Although the authors state that they have assumed for their readers no prerequisite training in science, the book will be of most value to the diligent student who is willing to put time and effort into his study of nutrition. The conciseness which characterizes the text calls for close and concentrated attention from the reader. The student may advance his knowledge and grasp of the various aspects of nutrition by referring to the carefully selected references given at the end of each chapter.

ANDREA MACKEY
Corvallis, Oregon

LITERATURE ON FOOD RESEARCH AND TECHNOLOGY*

* Material for this list should be sent to Dr. James G. Hodgson, Librarian, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

This new feature of the book section of FOOD TECHNOLOGY records new titles of interest to food scientists and technologists. For the most part the entries represent recent appearances in the United States and overseas.

COMMODITIES

Dictionnaire des huiles végétales, par Paul-H. Mensier. Paris, P. Lechevalier, 1957. 764 p. 10,000 F. fr. (Encyclopedia biologique, 52.)

Meat reference book; facts and figures about one of America's essential food industries and its important products. Chicago 5, American Meat Institute, 1957. 63 p. pap. apply.

For quick reference when questions are asked.

Studies on beef quality, parts I–III, by A. Howard and R. A. Lawrie. London, H. M. Sta. Off., 1957. 86 p. 6 s. (Gt. Br. Department of Scientific and Industrial Research. Food investigations special report no 63.)

Detailed report of investigations on improving quality of frozen beef exported from Australia.

Studies on beef quality, IV. Effect of blast-freezing of hot beef quarters and pre-slaughter injection of magnesium sulphide, by A. Howard and R. A. Lawrie. Melbourne, 1957. 16 p. pap. (Australia. Commonwealth Scientific and Industrial Research Organization. Division of Food Preservation and Transport. Technical paper no. 3)

Also published as Gt. Br. Department of Scientific and Industrial Research. Food investigations special report no. 64.

FOOD ENGINEERING

Automation; Its purpose and future, by Magnus Pyke. The Philosophical Library, New York, 1957. 191 p. $10.00.

Freezing preservation of foods; 3rd completely revised and augmented edition, by Donald K. Tressler and Clifford F. Evers. Westport, Conn., The Avi Publishing Co., 1957. 2 v. v. 1: *Freezing of fresh foods.* $18.00 v. 2. *Freez-*

Season's Greetings!
Robert S. Whiteside, President
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Dr. J. K. Krum
Asst. Tech. Dir.
L. R. Patton, Jr.
Asst. Sales Mgr.
Sylvester A. Ryan
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Kansas City
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C. L. Chapin
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D. L. Nunn
Kansas City
W. Quincy Isaacs
Kansas City
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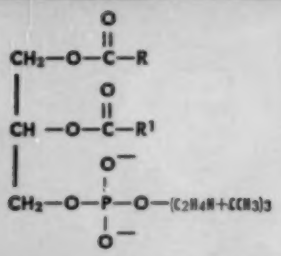

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General principles governing the use of food additives; Report of the joint FAO/WHO expert committee on food additives. First session, Rome, 1956. New York, Columbia University Press, 1957. 26 p. (FAO nutrition meetings. Report ser. no. 15.) pap. $0.30.

Sterilization in food technology, by C. Olin Ball and F. C. W. Olsen. New York, McGraw-Hill, 1957. 654 p. $10.00.

Food Technology

Advances in food research, v. 7, ed. by E. M. Mrak and G. F. Stewart. New York, Academic Press, 1957. 404 p. $9.50.

Biological Sciences

Advances in enzymology, v. 18, ed. by F. F. Nord. New York, Interscience, 1957. 441 p. $9.00.

Biochemical disorders in human disease, by Robert H.-S. Thompson and E. J. King. New York, Academic Press, 1957. 857 p. $12.50.

Disorders of nutrition, nerves and metabolism are discussed.

Biochemistry of the amino acids, by Alton Meister. New York, Academic Press, 1957. 499 p. $10.00.

Biological action of growth substances. H. K. Porter, ed. London, Cambridge University Presses; New York, Academic Press, 1957. 344 p. (Symposia of the Society for Experimental Biology, no. XI.) $9.50.

Treats of both plant and animal growth.

Fats, oils, detergents year book, 1956. W. O. Lundberg, ed. New York, Interscience, 1957. 1146 p. $45.00.

Hormonal regulation of energy metabolism, ed. by Lawrence L. Kinsell, M.D. Springfield, Ill., C. C. Thomas, 1957. 272 p. $5.25.

Chemical and Physical Sciences

Analytical microscopy of food and drugs; 2nd ed. by T. E. Wallis. Boston, Little Brown, 1957. 578 p. $5.50.

Annual report of the Hormel Foundation, 1956–57. (University of Minnesota.) Minneapolis, 1957. 80 p. pap.

Interim reports on research in progress, including a number of studies on fats and oils.

Chemisorption; Proceedings of a symposium held at the University College of North Staffordshire, by the Chemical Society, 1956. New York, Academic Press, 1957. 289 p. $9.00.

Edited by W. B. Garner.

Chemistry of natural food flavors: a symposium, sponsored by the National Academy of Sciences, National Research Council. Edited by Jack H. Mitchell, Jr., Norbert J. Leinen, Emil M. Mrak, and S. David Bailey. Chicago, Quartermaster Food and Container Institute, 1957. 200 p. pap. apply.

One of a series of "Surveys of progress on military subsistence problems" available from the Quartermaster Food and Container Institute, 1819 W. Pershing Road, Chicago 9, Illinois.

Experiments in biochemical research techniques, by Robert W. Cowgill and Arthur B. Pardee. New York, John Wiley, 1957. 198 p. $3.50.

For the advanced student. Includes biochemistry of enzymes and radioactive isotope tracer techniques in biochemical research.

Introduction to protein chemistry by Sidney W. Fox and Joseph F. Foster. New York, N. Y., John Wiley & Sons, Inc. $9.50.

Step-by-step development of fundamentals of protein chemistry, covering amino acids, peptides, proteins and other areas of knowledge basic to biology, nutrition, and food technology.

Vitamin A, by Thomas Moore. Princeton, N. J., Van Nostrand, 1957. $14.00. (Elsevier pubn.)

An intensive study of the chemistry, physics, physiology and biochemistry of Vitamin A and its provitamins. Describes the effects of its deficiency and its relationship to the functions of human beings, particularly its effects on the endocrine system and the sex hormones.

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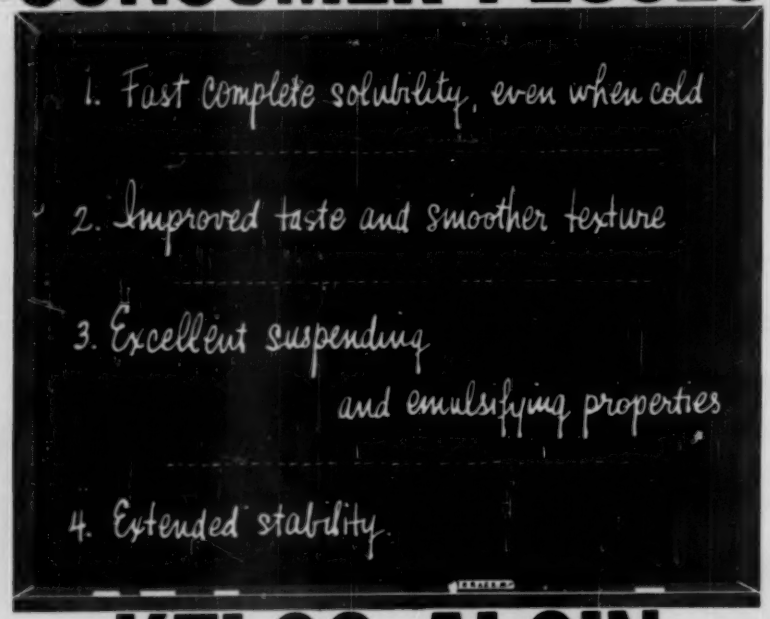
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Social, Legal and Economics

Costs of canning sweet corn in selected plants. Washington, U. S. Govt. Print. Off., 1957. 52 p. (U. S. Department of Agriculture. Marketing research report no. 184.) pap. apply.

Dietary levels of households in the West. Washington, U. S. Govt. Print. Off., 1957. 68 p. (U. S. Department of Agriculture. Household food consumption survey. 1955. Report no. 10.) pap. $0.40.

Dietary levels of households in the North Central region. Washington, U. S. Govt. Print. Off., 1957. 68 p. (U. S. Department of Agriculture. Household food consumption survey, 1955. Report no. 8.) pap. $0.40.

Dietary levels of households in the Northeast. Washington, U. S. Govt. Print. Off., 1957. 68 p. (U. S. Department of Agriculture. Household food consumption survey, 1955. Report no. 7.) pap. apply.

Dietary levels of households in the South. Washington, U. S. Govt. Print. Off., 1957. 68 p. (U. S. Department of Agriculture. Household food consumption survey, 1955. Report no. 9) pap. $0.45.

Food facts talk back; food information and fallacies and facts. Chicago, American Dietetic Association, 1957. 32 p. pap. $0.50.

Some important information in a style for popular consumption.

Miscellaneous

Matérial de façonnage des pâtes, par C. W. Brabender et autres. Paris, Centre de Formation Technique et de Perfectionnement de l'Union des-Fabricants de Biscuits, Biscottes, Aliments Diététque et Divers, 1957. 115 p. (Conférences données au cours du 2e cycle 1955.)

Bibliographies

Searching the chemical and chemical engineering literature, with an analysis of 229 journals and handbooks, by James van Luik and others. West Lafayette, Indiana, Purdue University, 1957. 208 p. pap. $1.40.

Selected bibliography of salt cod, by Marjorie E. McPhail. Halifax, Nova Scotia, Technological Station, 1957. 30 p. processed. Canada. Fisheries Research Board. Circular, new series, no. 5.)

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Infrared analysis of commercial butylated hydroxyanisole.

WHETSEL, K., KRELL, M. AND JOHNSON, F. E. (Tennessee Eastman Co., Kingsport, Tenn.). *J. Agr. Food Chem. 5*. 602–4 (1957).

An infrared method has been developed which allows the isomers of butylated hydroxyanisole (BHA) to be detd. with a standard deviation of approx. ± 1%.

BIOLOGICAL SCIENCES

Biochemistry

The purification and properties of hydropyrimidine hydrase.

WALLACH, D. P. AND GRISOLIA, S. (Univ. of Kansas Med. Center, Kansas City). *Biochem. J. 226*, 277–88 (1957).

A method is described for prepg., with good yields and with some 200-fold purification, the enzyme able to catalyze the enzymatic interconversion of carbamyl β-alanine or carbamyl β-aminoisobutyric acid to hydrouracil or hydrothymine, resp. The purified enzyme is able to convert hydantoin to carbamyl glycine at a rapid rate, but does not catalyze the reverse reaction. It is judged to be about 80% pure on the basis of electrophoretic and ultracentrifugal data. The possible relations of this enzyme to pyrimidine and hydantoin metabolism are discussed.

Lipoprotein lipase of chicken adipose tissue.

KORN, E. D. AND QUIGLEY, T. W. (Natl. Inst. of Health, Bethesda, Md.). *J. Biol. Chem. 226*, 833–9 (1957).

Lipoprotein lipase has been isolated from chicken adipose tissue. The hydrolysis of lipoproteins by this enzyme has been shown to occur in two stages: the formation of an enzyme-substrate complex and the actual hydrolysis. The first step exhibits a non-specific requirement for ions; the second step requires one of several specific cations. The relative specificity of the enzyme for the triglyceride of lipoproteins appears to be related to its greater affinity for lipoproteins than for simple triglycerides. The action of various inhibitors of the enzyme has been discussed.

An enzyme-catalyzed acyl migration: a lysolecithin migratase.

UZIEL, M. AND HANAHAN, D. J. (Univ. of Washington, Seattle). *J. Biol. Chem. 226*, 789–98 (1957).

The occurrence of a new type of lysolecithinase, a migratase, in exts. of *Penicillium notatum* and com. pancreatin is described. This enzyme catalyzed β to α′ migration of the fatty acid acyl group on a satd. lysolecithin. A similar non-enzyme-catalyzed migration could be induced by incubation of satd. lysolecithin in 0.05 *N* HCl for 12 hrs. at 25°. Cyanide was found to be a potent inhibitor of both the enzyme- and non-enzyme-catalyzed migrations. No action of this enzyme, or 0.05 *N* HCl, on an unsatd. lysolecithin could be demonstrated. A mechanism is proposed for the route of migration.

Activity and specificity of rennin.

FISH, J. C. (Univ. of Cambridge, Engl.). *Nature 180*, 345 (1957).

Rennin was found to be a powerful proteolytic enzyme with a specificity similar to that of pepsin.

The guanidination of some biologically active proteins.

GESCHWIND, I. I. AND LI, C. H. (Univ. of California, Berkeley). *Biochim. et Biophys. Acta 25*, 171–8 (1957).

The guanidination of pituitary growth and lactogenic hormones and of lysozyme is described. In all three instances guanidination has had no effect on the biological activity of the proteins. Acetylation of all three proteins was found to lead to inactivation; acetylation of the guanidinated derivs. does not result in inactivation. The results have been interpreted as indicating that the α-amino groups of these proteins are not necessary for biol. activity. For maintenance of the activity, what is essential is conservation of the positive charge on the lysine side chain, independent of whether this charge results from the presence of an ε-amino or a guanidino group. The results of preliminary data on the guanidination of insulin, α-corticotropin and ribonuclease have been presented. Some possible uses for the guanidinated derivs. have been suggested.

Biosynthesis of collagen. The influence of ascorbic acid on the proline, hydroxyproline, glycine, and collagen content of regenerating guinea pig skin.

GOULD, B. S. AND WOESSNER, J. F. (Massachusetts Inst. of Technol., Cambridge). *Biochem J. 226*, 289–300 (1957).

Skin regeneration in normal and scorbutic guinea pigs has been studied by quant. detns. of proline, hydroxyproline, and glycine in hydrolyzed autoclaved exts. of the granulation tissue. Considerable hydroxyproline formation, which has been taken as a measure of collagen formation, occurs in wounds of previously undepleted animals, even though maintained on a scorbutigenic diet. Impaired hydroxyproline formation appears to be one of the earliest manifestations of the withdrawal of ascorbic acid. Depleted animals restored to ascorbic acid at the time of wounding produce the bulk of hydroxyproline between the 6th and 8th days after wounding. Similar animals maintained on the scorbutigenic diet produce no hydroxyproline, but when ascorbic acid is administered to such animals 10 to 13 days after wounding, they produce relatively large amts. within 24 to

(Continued on page 38 following technical papers)

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Palatability of Chickens Fed Diets Containing Different Levels of Fish Oil or Tallow[a, b]

I. Evaluation by a Consumer-Type Panel

II. Evaluation by a Trained Panel

Doris Carlson, L. M. Potter, L. D. Matterson, and E. P. Singsen

Department of Poultry Science, University of Connecticut, Storrs, Connecticut

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Human Nutrition Research Division, Institute of Home Economics, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

(Manuscript received May 14, 1957)

It has been known for a long time that the flesh of poultry is subject to off-flavors imparted by certain feed ingredients, notably fish oils *(1, 2, 3, 5)*. Because fats and oils have assumed such importance in the formulation of broiler feeds, it appeared necessary to try to establish the amounts of certain commonly used fats and fish oils that could be safely used without adverse effects on the flavor of broilers. It was also necessary to determine whether or not off-flavors due to fish oils could be eliminated by the presence of antioxidants in the broiler feed or by feeding of a finishing ration without added fish oil for 3 weeks before marketing.

The palatability of chickens fed different experimental diets was evaluated by two distinctly different methods: (a) responses of consumers without taste panel experience who cooked the chickens in their homes using their own methods subject to certain restrictions and (b) scores of a trained panel on chicken cooked under carefully controlled conditions in the laboratory. One-half of each chicken was evaluated by the first method at the University of Connecticut and the other half by the second method at the Institute of Home Economics, U. S. Department of Agriculture.

I. EVALUATION BY A CONSUMER-TYPE PANEL

With these objectives in mind, the University of Connecticut Department of Poultry Science conducted two palatability experiments during the winter of 1955-56, the first one in conjunction with the Human Nutrition Research Division of the U. S. Department of Agriculture and the U. S. Fish and Wildlife Service. The basal rations in both experiments were practical corn-soya rations, the first containing 23% protein and the second 25% (Table 1). Both basal rations included 5% menhaden fish meal, which contributed 0.5% menhaden fish oil to the diet. The increments of fish oil or beef tallow used as variables were

TABLE 1

Composition of the basal diets

Ingredients	Experiment I	Experiment II [5]
	Lbs./100 lbs.	Lbs./100 lbs.
Ground yellow corn	59.34	53.35
Soybean oil meal (50% protein)	29.07	....
Soybean oil meal (48.6% protein)	....	35.06
Fish meal (60% protein)	5.00	5.00
Alfalfa meal (17% protein)	2.50	2.50
Dicalcium phosphate	1.50	1.50
Ground limestone	1.25	1.25
Iodized salt	0.50	0.50
Potassium chloride	0.25	0.25
Manganese sulfate	0.025	0.025
Dry vitamin A (5000 USP units/gm.)	....	0.10
Dry vitamin A (4000 USP units/gm.)	0.125	....
Dry vitamin D (3000 ICU/gm.)	0.05	0.05
Vitamin supplement [1]	0.10	0.10
Choline chloride (25% dry)	0.10	0.10
Vitamin B_{12} supplement [2]	0.20	0.20
Diphenyl-p-phenylenediamine	....	0.0125
Nicarbazin mixture (25%) [3]	....	0.0125
Procaine penicillin mixture [4]	0.6 grams	0.6 grams
TOTAL	100.010 lbs.	100.010 lbs.
Calculated analysis: Protein, %	23	25
Productive energy, Calories per lb. (Titus)	938	919

[1] Lederle's 2-49C guaranteed to contain 2 g. riboflavin, 4 g. calcium pantothenate, and 9 g. niacin per pound; manufactured by American Cyanamid Co., New York, N. Y.

[2] Proferm-6, guaranteed to contain 6 mg. vitamin B_{12} per pound; manufactured by Commercial Solvents Corporation, Terre Haute, Indiana.

[3] Nicarbazin mixture, manufactured by Merck and Company, Inc., Rahway, N. J.

[4] Propen "50%", guaranteed to contain 500 grams procaine penicillin per kilogram; manufactured by Merck and Company, Inc., Rahway, N. J.

[5] The finishing ration for Experiment II was formulated from the starting ration by reducing the soybean oil meal and increasing the ground yellow corn content of the starter by an amount sufficient to reduce the protein content to 20%. The other ingredients remained the same.

[a] Presented before the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1957.

[b] Research supported in part as a Saltonstall-Kennedy Act Fund Project of the U. S. Fish and Wildlife Service and a grant from the Tantic Grain and Products Company, Norwich, Connecticut.

added at the expense of an equal amount of yellow corn meal.

EXPERIMENT I

Diet variables. In the first experiment, 5 levels (from 0.5% through 8%) of menhaden fish oil or beef tallow were tested (Table 2). The antioxidants added as variables were DPPD (diphenyl-para-phenylene dinmine)[c] or BHT (butylated hydroxy toluene) at a level of 0.0125%. There were two control lots containing no added fat or antioxidant.

TABLE 2

Plan of experiment I

Fat:	Menhaden Fish Oil			Beef Tallow		
Antioxidant: [1]	0	DPPD	BHT	0	DPPD	BHT
% Fat added [2]						
0	L1	L7	L13	L19	L25	L31
0.5	L2	L8	L14	L20	L26	L32
1.0	L3	L9	L15	L21	L27	L33
2.0	L4	L10	L16	L22	L28	L34
4.0	L5	L11	L17	L23	L29	L35
8.0	L6	L12	L18	L24	L30	L36

[1] Added at 0.0125% level.
[2] Added at the expense of an equal amount of yellow corn meal.

Palatability procedures. Eight-week-old broilers were halved, tagged, individually wrapped in polyethylene bags, coded, and quick-frozen. Since one purpose of the University portion of this experiment was to evaluate the responses of persons who might be considered average consumers, of assumed discrimination but without taste-panel experience, 30 people were asked to participate in the test for a total of 5 trials spaced 3 days apart. Two or 3 half-chickens were provided from the lots on 0.5% through the 2% levels of fish oil, plus controls, to each consumer for each trial. Only these levels were tested, as pre-testing of the 4% and 8% levels by members of the Poultry Science Department proved conclusively that the broilers fed those levels of menhaden oil were offensively fishy and oily and that it would be both inconsiderate and valueless to include them in a test of this kind.

Participants were allowed to use their favorite recipes, provided they prepared the birds in separate pans and followed the printed instructions attached to each package to insure the identity and separation of samples. The taste-testers filled out questionnaires at the time of sampling, scoring the birds 1, 2, or 3, as to flavor, aroma, and tenderness, number one denoting the best. They were also asked to comment on any marked flavor, odor, or texture characteristics and to return the questionnaires within three days. The scores and comments were recorded, and the results were tabulated in terms of percentages based on the off-flavor reports. No attempt was made to evaluate the numerical scores statistically, because of the nature of the method of testing. It should be noted here that, although the participants knew they were testing a variety of feeding programs, they were not told the particular ingredients involved.

[c] DPPD is now not permitted by the Food and Drug Administration for use as an antioxidant in poultry feeds.

RESULTS

Fifty-three percent to 69% of the participants reported fishy, rancid, or strong off-flavors in the broilers fed 2% menhaden oil; and 30% to 42% reported fishy or other objectionable off-flavors in birds fed 1% menhaden oil (Figure 1).

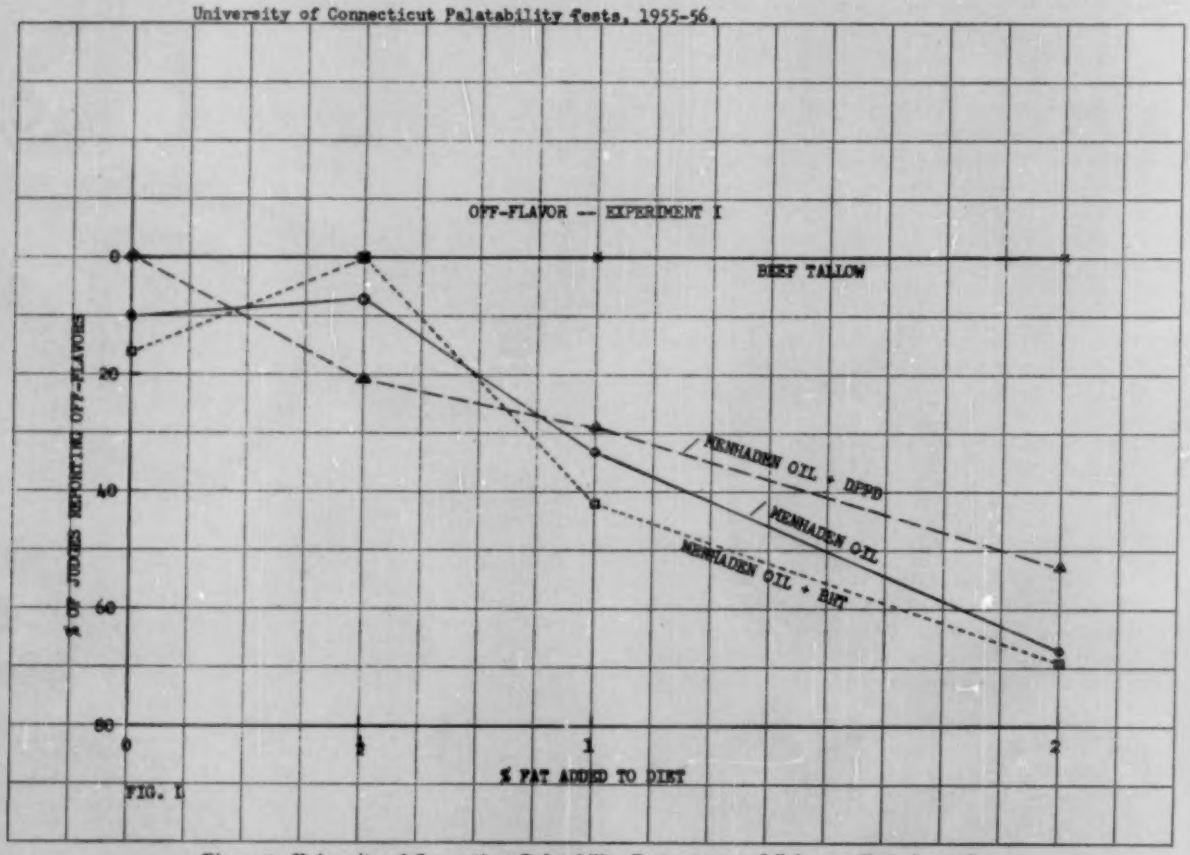

Figure 1. University of Connecticut Palatability Test, 1955-56, Off-flavor—Experiment I.

Although the lower range of percentages appeared to reflect a beneficial effect due to DPPD, the difference is not considered to be of practical importance, since such a large percentage of the taste-testers still reported off-flavors. The broilers fed 0.5% menhaden fish oil were well received; and the birds fed any level of tallow received a very good response.

EXPERIMENT II

Diet variables. In the second experiment, only the 1% and 2% levels of menhaden fish oil were tested, as these had been found in the first experiment to be the critical levels (Table 3). In addition, the 1% and 2% levels of red fish oil were tested, as well as the 2% level of tallow. There was one control lot. All lots were fed 0.0125% DPPD, which was included in the basal ration. A second objective in this test was to determine whether off-flavors could be eliminated by feeding the broilers a 20%-protein finishing ration, without any added fish oil, for three weeks before marketing. The starting and finishing rations of this experiment, like the basal ration of the first experiment, contained 0.5% menhaden oil from fish meal. The finishing ration was fed to half the birds from each lot from the 7th through the 10th weeks.

Palatability procedures. In this test, 3 halved birds, prepared as before, were sent out to each of 175 volunteers, presumed to represent average consumers. Each package of 3 half-birds included a comparison of two types of fat and a control, or two levels of the same type of fat and a control, both for birds fed the finisher and those not fed the finisher. Cross-comparisons were made between birds with and without the finishing program. There were 25 duplicates of each comparison; and the birds were scored and comments recorded as before. Results were tabulated by percentages for the test as a whole, based on the off-flavor reports. The evaluation of scores within comparison groups indicated that the type of comparison influenced the relative scores of the components of the group. Therefore, no graph has been prepared for the test as a whole on the numerical scores.

TABLE 3

Plan of experiment II (two replicates in each lot)

Fat:	Redfish Oil	Menhaden Oil	Beef Tallow
% Fat added [1]			
0	L1	....	....
1	L2	L4	....
2	L3	L5	L6

[1] Added at the expense of an equal amount of yellow corn meal holding protein constant.

NOTE: All birds received 0.125% DPPD.

RESULTS

Results obtained in the second experiment closely paralleled those obtained in the first (Figure 2). Fifty-four per cent of the taste-testers reported fishy off-flavors in the broilers fed 2% menhaden oil with DPPD, and 20% reported fishiness in the birds fed 1% menhaden oil with DPPD. The finishing ration definitely counteracted fishiness in the off-flavors due to these levels of menhaden oil, with the most noticeable improvement at the 2% level. However, there were still a few reports of fishiness, and these birds rated lower in acceptability than did the controls. On the other hand, the red fish oil at both 1% and 2% levels was well tolerated.

Because so many factors entered into the evaluations of tenderness, such as methods of preparation and individual pref-

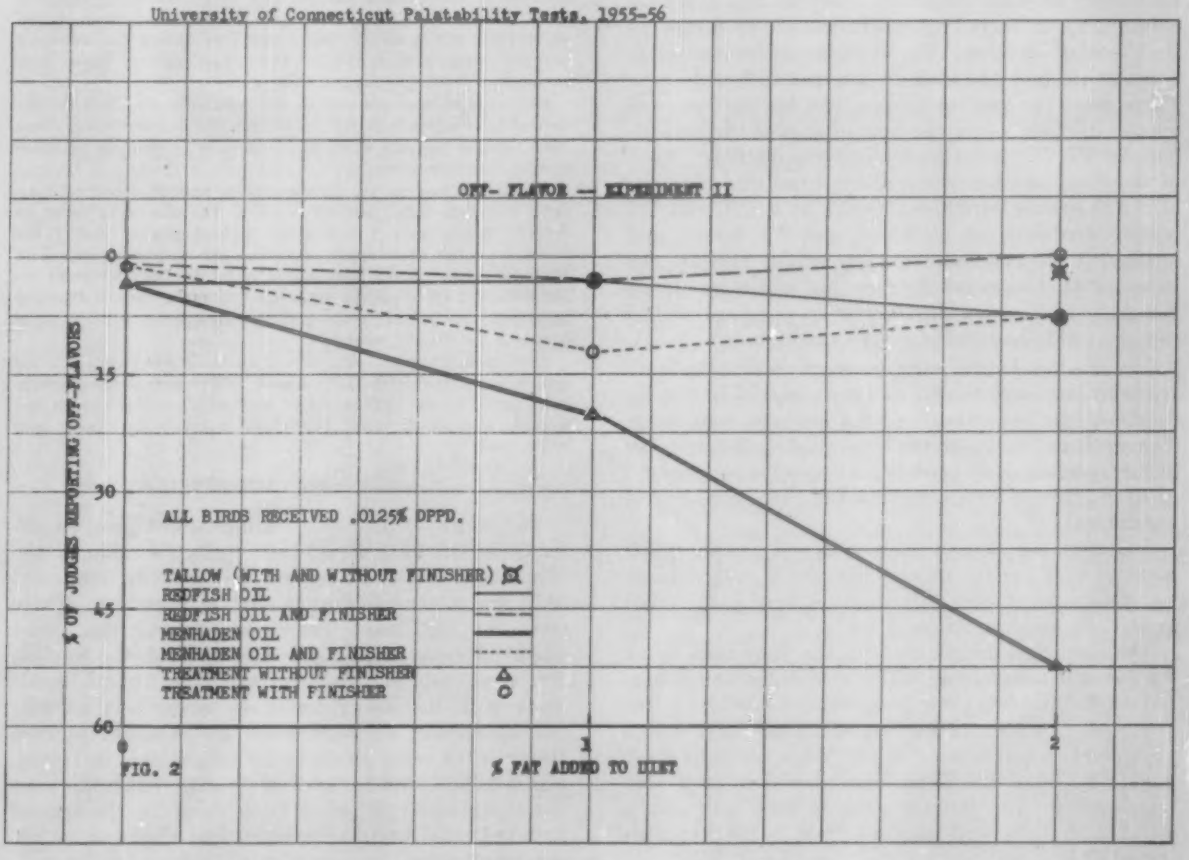

Figure 2. University of Connecticut Palatability Test, 1955-56, Off-flavor—Experiment II.

erences, no significant pattern of differences for that criterion could be plotted. However, the birds that were rated best in flavor tended also to be rated best in texture. Reports indicated that the birds fed 1% and 2% menhaden fish oil had a less savory aroma than any of the others tested. A fishy odor was reported in the broilers fed the 2% level of menhaden oil by more than 30% of the taste-testers.

The preference of the judges for the broilers fed beef tallow or 2% red fish oil with finisher suggests that the addition of 2% of fat to the broiler ration produces a pleasing flavor-tenderness relationship in the chicken when the substances that generate a fishy flavor are either not present or have been eliminated by the use of a finishing ration.

Results may be summed up briefly as follows:

1. Addition of 0.5, 1, or 2% beef tallow or of 0.5% menhaden fish oil in addition to the 0.5% in the basal diet did not result in more comments on objectionable off-flavors than were reported for the basal diet. Menhaden oil added at 1% and 2% imparted a fishy flavor and odor, which were only slightly less noticeable in the chickens fed 0.0125% DPPD.

2. Addition of 1% and 2% red fish oil did not impart an objectionable fishy flavor to chicken meat.

3. Feeding of a finishing ration without added fish oil for 3 weeks before marketing considerably improved the flavor of broilers previously fed 1% or 2% menhaden oil but did not completely eliminate the off-flavors.

II. EVALUATION BY A TRAINED PANEL

At the request of the U. S. Fish and Wildlife Service, the Human Nutrition Research Division of the U. S. Department of Agriculture cooperated with the University of Connecticut in studying the effect on palatability of including menhaden oil or tallow in the diets of chickens. The chickens under test were 8 weeks old and included 11 lots fed different diets. There were two control groups, one having been fed a basal diet, the other the basal diet plus the antioxidant DPPD (diphenyl-para-phenylene diamine). Each of the other lots had received the basal diet plus one of the following variables: Tallow at 0.5, 1, and 2% levels; menhaden oil at 0.5, 1, and 2% levels; and menhaden oil at these same levels plus DPPD. An extra lot of chickens of the same age and of one breed was purchased on the local market as an added control sample, making a total of 12 lots of chickens.

The chicken halves were packaged individually in polyethylene bags, frozen, and sent packed in dry ice to the U. S. Department of Agriculture laboratory. The chickens bought on the local market also were cut in half, packaged, and frozen. All samples were stored at 0° F. from 3 to 5 weeks during the course of the experiment.

To determine whether temperature of cooking might have an effect on the palatability of the cooked meat, two replicates of each diet variable were oven-cooked at 325° F., and two others at 400° F.

The statistical design used for the taste tests was a 3 x 4 simple rectangular lattice with different randomization for the two oven temperatures specifying the order of cooking and serving samples. This design provided two scores per diet per judge for light meat, dark meat, and skin from birds cooked at each oven temperature. The judging sessions were held once a day for 16 days, with samples from 3 diet variables served at each session.

PROCEDURES

Preparation and cooking of samples. In preparation for cooking, the frozen chicken halves were thawed in the refrigerator overnight, then brought to room temperature, washed, and dried with cheesecloth. The chicken halves were brushed with soft vegetable fat, laid skin side down on racks in shallow pans, and then placed in preheated ovens. Each sample, which consisted of 4 chicken halves of the same diet variable as close to the same weight as possible, was cooked in a separate oven. Samples were cooked for 75 minutes in ovens set at 325° F., or for 50 minutes at 400° F. At the midpoint of the cooking time the halves were brushed again with soft fat and turned. Separate sets of equipment were used throughout preparation and cooking for each set of samples to prevent the possibility of transfer of flavor from one sample to another.

Palatability evaluation. In the past, palatability evaluation of poultry has usually been made on small samples cut in the laboratory, often with samples from the same anatomical location given to the same judge. In this study an attempt was made to duplicate more nearly the normal situation in which chicken is used by the consumer. For this reason a half chicken from each sample was served to each panel member.

The palatability panel consisted of 4 home economists not employed on the poultry project. They were selected and trained in 6 preliminary sessions in which 9 prospective judges were served control samples and selected samples of chickens fed the experimental diets. Panel members were trained to carve their own samples, first tasting the light meat, then the dark, and finally the skin. Samples of light meat were cut from the thickest part of the breast, dark meat from the outside of the thigh at the thickest part, and skin was sampled from the thigh.

The hot chicken halves were served one at a time on warm coded plates. Ten-minute intervals were allowed between samples to lessen taste fatigue and to reduce the possibility of carryover of off-flavor from one sample to another. Apple slices were served to the panel members during the intervals between samples as a further precaution against flavor contamination from one sample to another.

Each judge was allowed to use whatever size sample she needed to make the required judgments, but in order to cut down taste fatigue she was encouraged to taste or swallow no more sample than necessary.

Moistness, tenderness, chicken flavor, and off-flavor of both light and dark meat, and off-flavor of the skin were rated on 5-point scales, with 5 indicating highest quality and 1 the lowest. In the preliminary sessions open discussion was held after the samples had been scored to set quality standards for the different levels on the scales and to make certain that the descriptive terms representing the various scores had the same meaning for all the judges.

Statistical analyses. Analysis of variance was applied to the evaluation of the palatability scores. Differences between means were tested by the application of Method II of the Duncan and Bonner test which yields confidence intervals for linear contrasts *(4)*.

RESULTS AND DISCUSSION

The effects of diet and cooking temperature on off-flavor in the light meat, dark meat, and skin of the chickens are shown in Table 4. Results with light meat only are presented graphically in Figure 3. There were no significant differences among the panel mean off-flavor scores for chickens fed the various levels of tallow. The regression of panel mean score with increasing levels of tallow was likewise non-significant, although there was a slight upward trend in the mean scores as the tallow level increased. Panel mean scores for each of the tallow samples were not significantly different from those for the control and indicated that the samples had slight or no observed off-flavor.

TABLE 4

Mean scores for off-flavor of light meat, dark meat, and skin of chickens fed various diets and cooked at two different oven temperatures

Kind of sample and diet variable	Oven temperature	Mean off-flavor scores [1]						Regression coefficient [2]
		Treatment level				Mean of all treatment levels	Overall mean	
		None (control)	0.5 %	1 %	2 %			
Light meat:	° F.							
Tallow	325	4.7 [3]	4.0	4.6	4.5	4.5		−.01
Menhaden oil plus DPPD		4.2	3.8	3.4	2.4	3.4	3.7	−.93*
Menhaden oil		4.4	4.0	2.4	2.5	3.3		−1.01*
Tallow	400	5.0 [3]	4.0	4.6	5.0	4.7		.15
Menhaden oil plus DPPD		4.7	4.4	3.5	4.2	4.2	4.2	−.36
Menhaden oil		4.4	4.1	3.5	2.9	3.7		−.78*
Dark meat:								
Tallow	325	4.2 [3]	4.0	4.9	4.6	4.4		.27
Menhaden oil plus DPPD		3.9	3.9	3.5	2.4	3.4	3.6	−.79*
Menhaden oil		4.0	3.8	2.0	2.5	3.1		−.84*
Tallow	400	4.6 [3]	4.1	4.8	5.0	4.6		.29
Menhaden oil plus DPPD		4.8	4.8	3.1	3.9	4.1	4.1	−.54
Menhaden oil		4.5	3.5	3.0	3.2	3.6		−.56
Skin:								
Tallow	325	4.1 [3]	3.6	4.5	4.1	4.1		.11
Menhaden oil plus DPPD		3.6	4.0	3.4	2.4	3.3	3.5	−.72*
Menhaden oil		4.2	3.8	2.2	2.4	3.2		−.99*
Tallow	400	4.4 [3]	4.0	4.4	4.5	4.3		.13
Menhaden oil plus DPPD		4.6	4.4	2.9	3.4	3.8	3.9	−.70*
Menhaden oil		4.4	3.2	3.6	2.8	3.5		−.69*
Test difference [4]		1.5				.7	.4	
Light meat:								
Tallow	Mean of	4.9 [3]	4.0	4.6	4.7	4.6		.05
Menhaden oil plus DPPD	both	4.4	4.1	3.4	3.3	3.8	4.0	−.60*
Menhaden oil	temperatures	4.4	4.1	2.9	2.7	3.5		−.90*
Dark meat:	"							
Tallow		4.4 [3]	4.1	4.8	4.8	4.5		.28
Menhaden oil plus DPPD		4.3	4.3	3.3	3.1	3.8	3.9	−.67*
Menhaden oil		4.2	3.6	2.5	2.9	3.3		−.70*
Skin:								
Tallow	"	4.2 [3]	3.8	4.4	4.3	4.2		.12
Menhaden oil plus DPPD		4.1	4.2	3.1	2.9	3.6	3.7	−.71*
Menhaden oil		4.3	3.5	2.9	2.6	3.3		−.84*
Test difference [4]		1.0				.5	.3	

[1] A score of 5 denotes no off-flavor; 4, very slight off-flavor; 3, slight off-flavor; 2, moderate off-flavor; and 1, strong off-flavor. Mean for each treatment level at each temperature based on 8 values.

[2] Asterisk indicates that the regression coefficient is significantly different from zero at the 5 percent level. The test difference for the values at 325° and 400° F. is .70; the test difference for the values for both oven temperatures combined is .50.

[3] Locally purchased market sample.

[4] Differences between individual means equaling or exceeding the test difference are significant at the 5 percent level of the Duncan and Bonner test.

The chickens fed the 0.5% menhaden oil diets also were not significantly different from the controls and had slight off-flavor. However, chickens which had received 1% or 2% menhaden oil in their diets, either with or without the antioxidant, consistently had lower mean scores, denoting more off-flavor, than the comparable control samples. The differences were significant in most cases for both light and dark meat and for the skin. Most of the regressions were significantly negative indicating a significant decrease in panel mean scores as the amount of menhaden oil used was increased. Mean scores for samples of light and dark meat and skin generally were higher when the antioxidant was present than when it was not included.

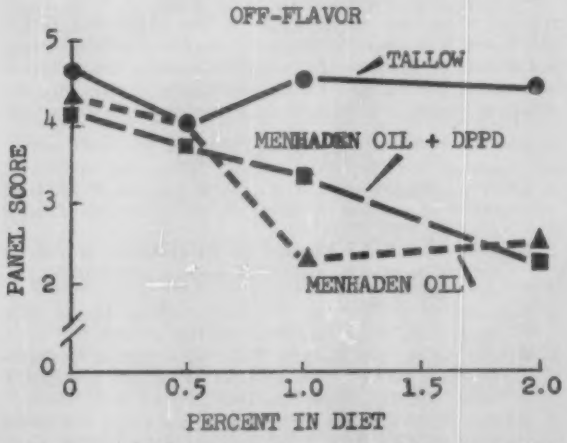

Figure 3. Off-flavor in light meat of chicken oven-cooked at 325° F.

Fishy off-flavors were noted by the judges in increasing numbers as the amount of menhaden oil in the diets was increased. The number of comments on fishy off-flavor decreased by about a third when the antioxidant was included in the diets. There is little doubt that the presence of the antioxidant resulted in higher ratings for at least the 1 and 2% levels of menhaden oil.

The overall means of off-flavor scores for chickens from all diet combinations cooked at 400° F. were significantly higher for dark meat, light meat, and skin than for those cooked at 325° F. (Figure 4). A relatively high oven temperature tended to overcome some of the deleterious effect of menhaden oil on flavor scores. A strong fishy odor present in the laboratory

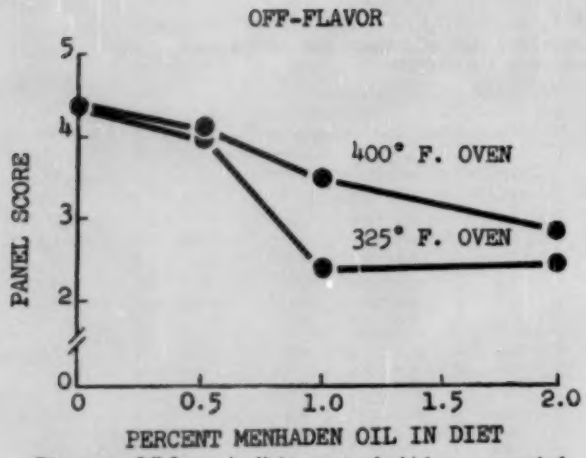

Figure 4. Off-flavor in light meat of chicken oven-cooked at 325° F. and 400° F.

during cooking of the chickens indicated that perhaps part of the fishy flavor was carried off in the volatile materials.

The mean scores for chicken flavor of the chickens fed the various levels of tallow, menhaden oil, or menhaden oil plus antioxidant were not significantly different from those of the corresponding control sample. However, there was a tendency for chickens fed the diets containing tallow to be scored higher on chicken flavor than those fed diets containing menhaden oil plus the antioxidant, and for the latter, particularly the dark meat, to be scored higher than chickens fed menhaden oil alone. In general, scores for chickens fed tallow at all levels indicated that these chickens had full natural chicken flavor. Those chickens fed menhaden oil at the 0.5% level had slightly full chicken flavor, but at the 1 and 2% levels the scores generally fell within the range indicating slightly weak natural flavor. The control lot of chickens bought on the local market received slightly higher scores than the chickens fed the basal diet or those fed the basal diet plus the antioxidant. All of the controls, however, had a normal amount of natural chicken flavor.

There were no statistically significant differences in tenderness or moistness associated with diet. Tenderness and moistness scores for dark meat were slightly higher than for light meat, but samples of both kinds of meat ranged from slightly tender to tender and from slightly moist to moist.

The data on chicken flavor, tenderness, and moistness did not exhibit any significant downward trend in panel mean scores with increasing levels of tallow, menhaden oil, or menhaden oil with antioxidant.

Results of the palatability evaluation made by the trained panel indicate that there were no significant differences in the off-flavor of chickens fed 0.5, 1 or 2% tallow or 0.5% menhaden oil with or without DPPD and the corresponding control samples. Pronounced off-flavors in the chickens fed diets containing 1 or 2% menhaden oil were observed. The use of the antioxidant, DPPD, appeared to be of some benefit in preventing the off-flavor accompanying use of the larger amounts of menhaden oil. Cooking at a relatively high temperature (400° F.) was an effective way of decreasing the off-flavor present. Effect of diet or cooking temperature on chicken flavor, moistness, or tenderness was not statistically significant.

SUMMARY

One-half of each chicken fed different experimental diets was taste-tested at the University of Connecticut by a consumer-type panel and the other half at the Institute of Home Economics by a trained panel.

The consumer panel used 3-point scales for scoring flavor, aroma, and tenderness and recorded comments on any marked quality characteristics. Results were presented in terms of percentages based on the off-flavor reports.

The trained panel used 5-point rating scales and recorded comments on moistness, tenderness, chicken flavor, and off-flavor. Results were evaluated by analysis of variance and significant differences between means were determined.

Similar overall conclusions were drawn from the consumer study and the laboratory study with respect to the amount of menhaden fish oil or tallow that can be added to the diet without impairing the flavor of broilers. The laboratory study found that chickens fed 1 or 2% menhaden fish oil with or without DPPD had significantly more off-flavor than the controls; those fed 0.5% menhaden fish oil with or without DPPD in addition to the 0.5% in the basal diet were not significantly different from control samples. Where 0.5, 1, or 2% tallow was added to the diet, chickens had very slight or no observed off-flavor. The consumer study found that the addition of 1% or 2% menhaden oil with or without DPPD added to the basal diet resulted in fishy off-flavors; the amount of off-flavor in diets containing 0.5% menhaden oil, without DPPD, was similar to that for the basal diets; and the addition of 0.5, 1, or 2% tallow to the basal diet resulted in no objectionable off-flavors.

ACKNOWLEDGMENTS

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The Chemical Evaluation of the Pungency of Onion and Garlic by the Content of Volatile Reducing Substances[a]

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PREVIOUS STUDIES on the quantitation of the pungency of onion and garlic have mainly depended upon the determination of the volatile sulfur content *(1, 4, 7, 8)*. These have been based on the concept that the constituents responsible for onion and garlic odor and flavor were sulfur compounds which could be separated by distillation *(9, 10)*. A study of the gaseous constituents of onion has recently appeared *(6)* in which vapor chromatography, mass spectrometry, and infra-red spectrometry have been used to identify a number of the volatile sulfur and other compounds.

The methods hitherto proposed for the quantitative estimation of the pungency of onion and garlic have involved many preparative steps and hence are time consuming. Their plant-laboratory adaptation for testing of many samples is therefore not too practical.

A procedure for the determination of the content of constituents volatile at room or ambient temperatures has been described *(5)*. In a survey of its more general applicability *(2)* it was shown (a) that onions and garlic contain substances volatile at ambient temperatures which are able to reduce alkaline potassium permanganate solutions and (b) that the content of these volatile reducing substances (VRS) diminished at the same time as the organoleptically judged pungency.

The present report represents a somewhat more detailed study of the applicability of the VRS method to evaluate the pungency of onion and garlic. Its chief purpose is to attract the attention of those food technologists directly concerned with the problem to the usefulness of the VRS procedure as a fast, easily-carried out quantitative technique to complement and supplement the organoleptic judgment of the pungency of onion and garlic products. No attempt has been made to standardize the procedure, to set up practical ranges of values, or otherwise to adapt the method for practical every day application.

EXPERIMENTAL PROCEDURE

Description of the method. The basic premise of the method was that odoriferous substances which could be smelled were volatile at ambient temperatures and were generally oxidizable by an alkaline potassium permanganate solution. The volatile substances were therefore aspirated from a sample by a current of air into the alkaline solution of potassium permanganate, which became reduced. The amount of potassium permanganate reduced was used as the measure of the content of volatile material.

The original apparatus *(2, 5)* has since been simplified. The flowmeter, air purification train, and one of the two reaction flasks have been eliminated and a closed circuit system has been set up. The volatile constituents in a sample in the aeration flask (A) are blown through the alkaline potassium permanganate solution in the reagent flask (B) and the scrubbed air is returned to the aeration flask for recirculation by a small recirculating pump (C) requiring no lubrication.[b] In this manner the approximately 2 liters of air in the system is kept recirculating for the duration of a run. A single unit apparatus is shown in Figure 1 and a multiple unit set-up in Figure 2. Any number of these multiple units may be assembled for large scale analyses.

Preparation of sample. Fresh onions and garlic were squeezed through absorbent gauze and 5 ml. of the press juice was used. Weighed amounts of dehydrated powders were mixed with distilled water and diluted to various concentrations and 5 ml. of the extracts were used. The active principles were ap-

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pa., May 14, 1957.

[b] For example, a Dyna-Pump.

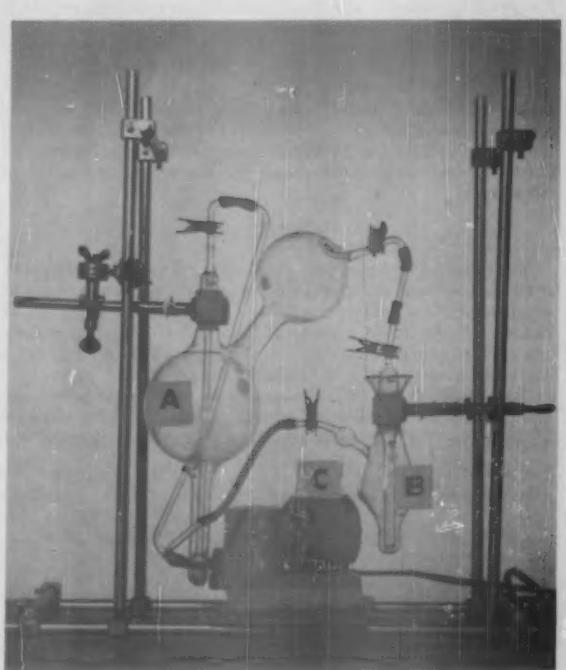

Figure 1. A single unit apparatus for the determination of VRS, showing aeration flask, A, reaction flask, B, and circulating pump, C.

Figure 2. A multi-unit VRS apparatus.

parently rapidly released *(3)*, since extraction periods up to an hour did not increase the content of volatile material over that found after a minute. Liquid preparations which were pipettable were used as such; aliquots of more viscous ones were weighed directly into the aeration flask by weight difference and diluted to a 5 ml. volume with distilled water.

Technical procedure. The 5 ml. sample in the aeration flask was aerated into 10 ml. of potassium permanganate in *N* sodium hydroxide solution. After the aeration period, 5 ml. of 6N sulfuric acid, followed by 3 ml. of 20% potassium iodide in 0.1% sodium carbonate solution were added to the oxidizing reagent, and the air inlet tube was rinsed free of iodine with distilled water. The liberated iodine was titrated with sodium thiosulfate in 0.2% sodium carbonate-0.1% sodium borate solution, using 5 drops of 1% soluble starch in a saturated sodium chloride solution as inside indicator. Along with the test run an unaerated and an aerated control were also set up. The latter was carried out by aerating 5 ml. of distilled water into the reagent for the same period as the test run. If the apparatus was properly cleaned and no extraneous atmospheric pollution was present, the titration for the unaerated control in the reagent flask was usually very close to that for the aerated control and was ordinarily used as the initial value of the permanganate. If an appreciable difference occurred, the aerated control was used. The difference between the control and test titrations multiplied by 1000 times the normality of the sodium thiosulfate solution gave the amount of microequivalents of potassium permanganate reduced by the volatile material in the sample.

RESULTS

The course of the aeration, showing the rate of VRS recovery with time, of raw onion press juice and of aqueous extracts of dehydrated onion and garlic powders is shown by the data of Tables 1–3. In Table 3 garlic preparation C was apparently a poorer garlic powder than B, since aqueous extracts of C had a markedly weaker garlic odor than those of B.

The effect of the concentration of the potassium permanganate reagent on the recovery of VRS is illustrated by the data of Table 4. The effect of permanganate concentration, as well as of the volume of extract aerated and of the aeration time are exemplified by the data of Table 5. The greater strength of the garlic powder extract is clearly evident, compared to that of the onion powder. The VRS contents found in 5 ml. of various concentrations of a garlic powder are shown in Table 6. Here the proportionality between VRS recovery and concentration of extract begins to decrease after about a 1% extract. As in the data of Tables 4 and 5, here too the effective concentration of permanganate in the reagent is a controlling factor on the yield.

In Table 7 are shown the VRS contents of 3 different commercial onion powders and of four garlic powders. Onion lots A and C gave extracts with much weaker onion odors than did lot B, with A having somewhat less odor, although not markedly so, than C. Garlic lots A and D gave aqueous extracts with similar odor intensities; the extracts of B were markedly stronger than of any of the others, and lot C extract had the least garlic odor of any of the powders. The correlation between the organoleptic judgment and chemical evaluation is quite evident.

Another series of commercial garlic preparations was evaluated organoleptically and chemically with the results shown in Table 8. The extract of the powder had the strongest garlic

TABLE 1

Rate of recovery of VRS from raw onion press juice

Aeration time minutes	VRS Microequiv'ts redn.	
	per 5 ml.	per 5 min.
5	19.1	19.1
10	25.2	12.6
20	40.2	10.0
30	49.5	8.2
40	56.1	7.0

$KMnO_4$ concentration: 0.033 N.

TABLE 2

Rate of recovery of VRS from aqueous extracts of dehydrated onion powder

Aeration time minutes	VRS Microequiv'ts redn. per 5 ml. aqueous extract		Ratio of VRS values
	4%	10%	
5	15.0	37.6	2.50
10	30.0	70.0	2.33
15	37.0	97.0	2.62
20	42.5	116.0	2.73
30	55.0	146.5	2.67
40	64.0	173.7	2.69
50	71.0	192.0	2.70
60	.....	204.1	

$KMnO_4$ concentration used: 0.05 N.

TABLE 3

Rate of recovery of VRS from 2% aqueous extracts of dehyrated garlic powders

Aeration time minutes	VRS Microequiv'ts reduction per 5 ml. of		Ratio of values
	Prep. B	Prep. C	
5	19.1	10.3	1.85
10	34.5	16.0	2.16
20	51.5	21.6	2.38
30	66.5	25.2	2.64
40	82.5	31.4	2.62

$KMnO_4$ concentration: 0.049 N.
Prep. C extract had a weaker garlic odor than did prep. B.

TABLE 4

Effect of $KMnO_4$ concentration on the recovery of VRS from aqueous extracts of dehydrated onion

Concn. of extract %	VRS Microequiv'ts reduction per 5 ml.	
	0.03 N	0.094 N
0.5	9.0	19.7
0.8	17.7	31.9
1.0	20.0	32.8
1.2	24.6	40.0
2.0	36.5	55.6
4.0	42.0	80.5
5.0	49.9	95.7
10.0	55.9	.....

Aeration time: 20 minutes.

TABLE 5

Recovery of VRS from varying volumes of 8% aqueous extracts of dehydrated onion and garlic

Volume of extract per 5 ml.	VRS Microequiv'ts reduction from			
	Onion		Garlic	
	per 5 ml.	per ml.	per 5 ml.	per ml.
0.5	....	....	17.4	34.8
1.0	8.3	8.3	34.8	34.8
2.0	14.2	7.1	42.2	21.1
3.0	25.0	8.3	55.0	18.3
4.0	32.0	8.0	62.0	15.5
5.0	42.2	8.4	75.0	15.0

Onion: $KMnO_4$ concn. 0.05 N, aeration time 15 min.
Garlic: $KMnO_4$ concn. 0.03 N, aeration time 20 min.

odor of the three. The puree had a definite garlic odor, and even though it seemed to be of a somewhat lesser intensity than that of the powder, it was difficult to judge them quantitatively by organoleptic means.

Extracts of a number of different onion and garlic powders were prepared; aliquots were boiled for 5 minutes and made up to the original volumes with distilled water. Five ml. of the extracts (before and after boiling and making to volume) were aerated and the VRS contents found are given in Table 9. The various onion and garlic extracts had lost practically all of their noticeable characteristic odors after boiling; nevertheless there remained betwen 6.5 and 16.4% of the VRS content in

TABLE 6

Recovery of VRS from aqueous extracts of dehydrated garlic

Concn. of extract %	VRS Microequiv'ts per 5 ml.
0.5	16.0
1.0	30.0
2.0	51.5
4.0	65.0
8.0	87.0

$KMnO_4$ concn. 0.045 N; aeration time 20 min.

the onion extracts and between 15 and 18.6% of the original VRS in the garlic extracts.

Onion slices and an onion press juice were stored in open vessels at an ambient temperature averaging 23° C. and their VRS contents were periodically determined. The data of Table 10 show that 75% of the volatile material of the press juice was lost after 24 hours; about 44% and 65% of the VRS content of onion slices was lost after an 18-hour and a 6-day storage period, respectively.

The possibility that sulfur dioxide-treated dehydrated onion and garlic powders could give distorted values for their VRS content was studied to a limited extent. It was found that a 5% aqueous extract of a dehydrated onion powder to which had been added 148 p.p.m. of sulfur dioxide as sodium bisulfite did not give any extra VRS above the untreated sample; however, after acidification with a sulfuric acid solution the treated preparation had a marked increase in VRS content. The relationship between the concentration of added sulfur dioxide as sodium bisulfite and the increase in VRS content of acidified over non-acidified extracts is illustrated in Table 11. It is evident that the extra VRS content increases with an increase in sulfur dioxide content of the acidified extracts.

TABLE 7

VRS in 4% aqueous extracts of dehydrated onion and garlic powders

Lot No.	VRS Microequiv'ts per 5 ml. from		Organoleptic judgments of extracts	
	Onion	Garlic	Onion	Garlic
A	18.4	36.0	Similar to C, weaker	Def. garlic odor
B	46.0	50.5	Def. onion odor	Strong garlic odor
C	21.2	19.2	Weak onion odor	Weak garlic odor
D	.....	37.4	.....	Similar to A in odor

$KMnO_4$ concn. 0.033 N; aeration times: onion 20 min., garlic 30 min.

DISCUSSION

On reviewing the above data it became evident that the recovery of VRS from onion and garlic preparations was dependent upon the time of aeration, concentration of extract, and particularly, upon the concentration of potassium permanganate in the oxidizing reagent. In Table 1 the recovery per 5-minute interval steadily decreased with increase in aeration interval and concurrently with a decrease in available permanganate in the reagent. This was also evident from data of Tables 2–6. In Table 2 it is shown that the recovery of VRS was linear up to 10 minutes for the weaker 4% extract, but began to fall away from direct proportionality after 5 minutes for the stronger 10% extract. However, the ratio of VRS values for the two concentrations remained approximately the same, indicating that comparable amounts of VRS were recovered for each aeration time, and that the two extracts could have been compared with similar results by aerating them for various times. A similar situation was found for the two garlic powders studied in Table 3. Here also the recovery rate decreased with increasing aeration time and decreasing permanganate concentration in the reagent, but the comparative VRS values were approximately the same for the various aeration times. A difference in type of material with a corresponding effect on volatility is also indicated by the shorter times. The marked influence of the potassium permanganate concentration was shown by the data of Table 4. With increasing concentration of onion powder in the aqueous extracts

TABLE 8

VRS in various garlic preparations

Sample	VRS Microequiv'ts per gram	Organoleptic judgment of samples aerated
Puree	83.0	Definite garlic odor
Liquid sauce	76.0	Definite, though mild odor
Powder	124.3	Strongest garlic odor

Aeration time: 15 minutes; $KMnO_4$ concn. 0.05 N; total volume 5 ml.

TABLE 9

Effect of boiling 1% aqueous extracts of onion and garlic powders on the VRS content

Lot No.	VRS Microequiv'ts per 5 ml.			
	Before boiling		After boiling	
	Onion	Garlic	Onion	Garlic
1	17.0	51.7	1.5	9.6
2	34.7	85.0	5.7	12.7
3	32.4	.....	2.1	.....
4	.....	69.9	....	12.2

$KMnO_4$ concn. 0.046 N; aeration times: onion 40 minutes, garlic 30 minutes; boiling time: 5 minutes.

TABLE 10

Effect of storage at ambient temperature of raw onion slices and press juice on the VRS content

Storage time	VRS Microeqniv'ts per gram or 5 ml.		Organoleptic judgments	
	Slices	Press juice	Slices	Press juice
0	113.0	56.1	Strong odor	Strong odor
18 hours	64.0	.....	Weaker but def.	.....
24 hours	.	14.4	.....	Very mild odor
6 days	40.0	.....	Still weaker but still like onion	.....

$KMnO_4$ concn. 0.042 N; aeration time 40 minutes.

the recovery was greater with the stronger permanganate than with the weaker one; yet the proportional increase of VRS recovery with increasing concentration dropped. However, the decrease in yield with concentration of extract was less with the 0.094 N than with the 0.03 N potassium permanganate solution. This controlling effect of the permanganate concentration on VRS recovery was also evident from the data of Table 5, where the volume of extract per ml. total volume was compared with the VRS recovery. For the weaker onion extract and with the stronger permanganate solution and the shorter aeration time the recovery of VRS was linear up to 5 ml. of extract. On the other hand, for the stronger garlic extract, and

TABLE 11

The effect of added SO_2 as $NaHSO_3$ on the VRS content of a 5% aqueous extract of dehydrated onion

SO_2 added p.p.m.	Increase in VRS above control without SO_2 Microeqniv'ts per 5 ml.
11.7	3.0
58.5	34.9
148.0	127.0
175.5	154.5

$KMnO_4$ concn. 0.03 N; aeration time 40 minutes.

using a weaker permanganate solution and a longer aeration time, the recovery rate decreased progressively for amounts of extract greater than 1 ml. A similar reasoning applied to Table 6, where with concentrations greater than about 1% the recovery rate of VRS dropped.

From the data of Tables 2–8 it was evident that the VRS procedure offered a means to quantitatively evaluate onion and garlic preparations of different concentrations or of diverse nature. Preparations could be compared quantitatively, in contrast to the organoleptic judgments, which though similar were yet not amenable to a numerical evaluation.

All of the above data definitely fulfill the main purpose of this exploratory study. The VRS method offered a useful means to compare and quantitatively evaluate the strength or pungency of different lots or samples of onion and garlic, to ascertain the possible effect of certain treatments on the pungency, such as boiling, and to test for the possible presence of adulterants or extraneous substances, such as sulfur dioxide.

The optimum conditions for carrying out the above purposes, including sample preparation, concentration of oxidizing reagent, and aeration time, will have to be determined by the individual investigators to fit their particular requirements.

SUMMARY

The applicability of the volatile reducing substances (VRS) procedure to the quantitative evaluation of the pungency of onion and garlic has been illustrated. The aeration time, the concentration of sample and of the alkaline potassium permanganate oxidizing reagent all affected the amount of VRS recovered from various onion and garlic preparations; each of these will have to be established, however, to suit particular experimental conditions.

Boiling aqueous extracts of dehydrated onion and garlic markedly decreased the characteristic odors and the VRS contents. The presence of added sulfur dioxide of 25 p.p.m., or even lower concentrations, could be detected by the increase in the reduction of the permanganate by acidified over that of nonacidified samples.

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Factors Affecting Quality of Prepackaged Meat[a, b]

II. Color Studies. C. Effects of Air and Oxygen under Different Pressures upon Color of Product.

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In the studies on the effect of temperature variations on meat, it was found that samples stored under a vacuum of 27 inches returned to redness. Therefore, experiments were designed to study the effect of vacuum variations at constant temperature. Ground samples of fresh meat and of cured ham were stored in desiccators under different pressures of air while the temperature was maintained constant at 34° F.

PROCEDURES

Storage in Desiccators. In some runs,[c] samples were stored in desiccators so that the atmospheres surrounding the samples could be controlled when the independent variable was to be either the degree of vacuum or the individual partial pressures of mixed gases. The desiccators were stored at 40° F. at least one day prior to packaging day so that their temperature would be approximately that of the storage cabinet. After the samples had been placed in the desiccators, the covers were put on and the atmosphere within adjusted to produce the desired conditions in respect to composition of gas and to pressure. The desiccators were then stored under refrigeration. In runs where the effect of vacuum on color change was to be determined, the desiccators were prepared as follows: 500 ml. of water was placed in the bottom of each desiccator to maintain a constant relative humidity. Two short pieces of glass tubing were inserted into the stopper of each desiccator lid and a short piece of rubber tubing was forced over the upper end of each piece of glass tubing. Pinch clamps were placed on each piece of rubber tubing for sealing after vacuum was drawn. After the samples were placed in a desiccator and the lid put in place, the vacuum pump connection was attached to one of the tubes of the desiccator stopper and a mercury manometer connection attached to the other tube in the desiccator stopper. Vacuum was drawn by the vacuum pump and measured by the mercury manometer. When the desired vacuum was reached, the two pinch clamps were closed, the connections removed, and the desiccator stored.

When the proportions of the different gases were not deliberately changed, the partial pressures of oxygen and carbon dioxide were calculated from a knowledge of the normal percentages of these gases in air and the pressure within the desiccator. In some runs, the percentages of oxygen, carbon dioxide, and nitrogen within the desiccators were changed from those of normal air. This was accomplished by drawing a partial vacuum in the desiccator and bringing it back to atmospheric pressure with one of the gases from a cylinder of compressed gas. The partial pressures of the gases were then calculated from the specifications of the procedure.

As a desiccator was removed from storage, the gauge pressure within was determined by means of a mercury manometer which was attached to one of the tubes inserted in the stopper of the cover. Outside atmospheric pressure was obtained with a barometer and the absolute pressure within the desiccator was calculated.

A sample of gas was taken from the desiccator through glass tubing with a stopcock. After this tube had been attached to the sampling bulb of a gas analysis apparatus, with the stopcock open, the mercury was raised in the sampling bulb by means of a leveling bulb until it flowed into the sampling line and reached the stopcock. The stopcock was then closed and the end of the sampling line was connected to the tubing in the desiccator stopper. The leveling bulb was lowered, the pinch clamps on the rubber tubing in the desiccator stopper opened, and the gas sample taken into the sampling bulb over mercury. The sampling bulb was then attached to the gas analysis apparatus. In the later work, the stopcock was omitted from the sampling tube and mercury was merely made to fill the sampling tube before the latter was connected to the desiccator.

Carbon dioxide was determined by absorbing the sample gas with potassium hydroxide.[d] Oxygen was determined by absorption with alkaline pyrogallate. The percentage of nitrogen in the gas sample was then computed by difference, and from the value of the pressure in the desiccator, the partial pressure of each gas was calculated. These were reported in centimeters of mercury.

After the gas was analyzed, the meat was removed from the dessicator and the redness determined by the Hunter Color and Color-Difference Meter as previously described.

Desiccators containing samples under a common storage condition were distributed between different temperature regions within the storage cabinet so that one member of each set of duplicates was stored at one average temperature and the other member at the other average temperature.

Fresh meat samples used in Runs R, S, U, GG, HH, II, JJ, and KK came from animals that were raised and slaughtered by the Department of Animal Husbandry, Rutgers University. The samples were prepared in the manner described in Section IA of this report. Cured ham and fresh beef samples used in Runs 1, 2, 3, 4, and 6 were purchased at a retail market and were ground or sliced to make samples of about 100 g. each.

RESULTS

Fresh Meat

Variation in Vacuum (Runs R, S, HH, and KK). It was found that the lower the pressure, the more rapid was the initial loss in redness. Even more significant was the observation that samples stored at the lower pressures (8.6 to 10.7 cm.) returned to the initial redness value in 7 days while the samples

[a] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act.

[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Technology and Animal Husbandry, New Brunswick, N. J.

[c] For a complete description of the various runs, see Food Technology, 11, 277-284 (1957).

[d] It is kept in mind that while potassium hydroxide is specific for carbon dioxide, it will, in addition absorb hydrogen sulfide, sulfur dioxide, and any other acid gases that may be present. In compiling these results, it was assumed that carbon dioxide was the only such gas present.

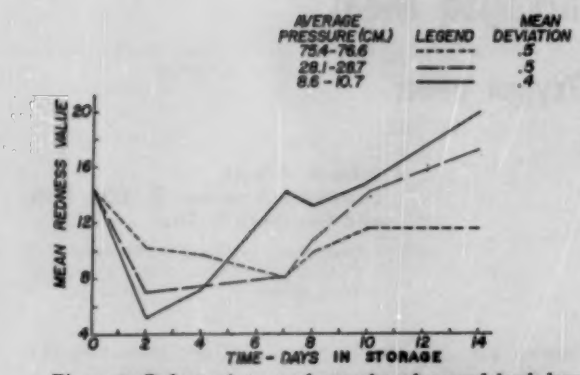

Figure 1. Redness changes of unpackaged ground lamb lean samples stored in low pressures of air. (Top of samples; 2 replicates). Run R.

stored at higher pressures (28.0 cm.) returned to initial redness values in 10 days. Samples stored at atmospheric pressure (76.0 cm.) underwent only a partial return in redness after 7 days.

Figure 1 shows the redness changes of the top surfaces of unpackaged ground lamb lean samples stored in air at 75.4 to 76.6 cm., 28.1 to 28.7 cm., and 8.6 to 10.7 cm. of mercury pressure in Run R. The lower the pressure, the greater was the initial loss of redness.

Figure 2 shows the effect of vacuum on the redness changes of ground fresh lean ham samples sealed in cans under vacuum and stored at 38° F. to 42° F. in Run S. An attempt was made to seal one series of cans at 27 inches and another series at 15 inches of vacuum. The vacuum was determined within the cans at each removal and was found to range from 18 to 22 inches in the higher vacuum series and from 8 to 16 inches in the lower vacuum series. The larger range that occurred in the lower vacuum samples was attributed to difficulty in obtaining a constant vacuum in the cans at the time of sealing at this low vacuum.

Figure 3 shows the redness values of unpackaged ground lean lamb samples stored in desiccators in air initially at 75.5 cm. and 25.1 cm. of mercury pressure in Run HH. No determinations were made between the 3rd and 14th days.

It should be kept in mind that although the desiccators containing the ground lamb samples were sealed initially at 75.5 cm. and 25.1 cm., the pressures within each individual desiccator varied in respect to time of holding as did the percentages and partial pressures of carbon dioxide and oxygen. In cases where large increases in pressure occurred in desiccators stored initially under vacuum, leakage of air from the surrounding atmosphere was probably responsible.

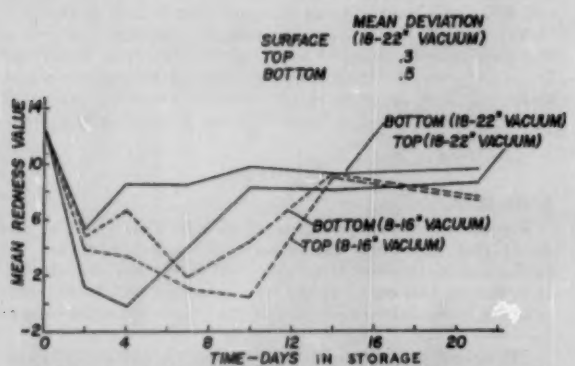

Figure 2. Redness changes of ground ham lean samples sealed in cans at different vacuums. (Top and bottom of samples; 2 replicates for 18-22 in. vacuum series; 1 sample for 8-16 in. vacuum series). Run S.

Table 1 shows the pressures, percentages by volume of carbon dioxide and oxygen, and partial pressures of carbon dioxide and oxygen calculated from the percentages within each desiccator sealed originally at 75.5 cm. and 25.1 cm. of pressure calculated initially and measured at the 4 removals in Run HH. There was apparently considerable leakage in the desiccator sealed at 25.1 cm. and examined at 14 days, and still more leakage in the desiccator examined at 17 days. Although the percentage of oxygen decreased between 14 and 17 days, the partial pressure of oxygen increased during this time. This discrepancy was due to the large increase in total desiccator pressure between 14 and 17 days.

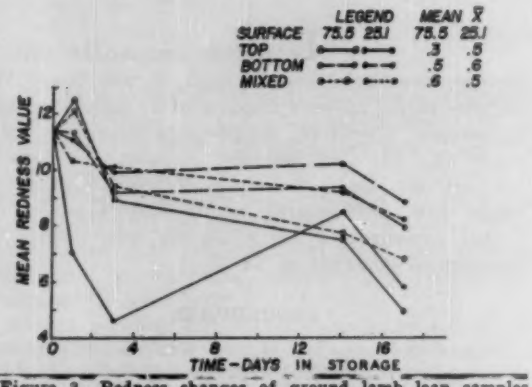

Figure 3. Redness changes of ground lamb lean samples stored initially at 75.5 cm. and 25.1 cm. pressures of air. (3 replicates). Run HH.

Figure 4 shows the redness values of the top surfaces of unpackaged ground lean pork samples stored in desiccators in air initially at 76.8 cm., 37.8 cm., and 12.2 cm. of pressure in Run KK. It will be noted that the initial redness values of the pork samples were extremely low.

Table 2 shows the pressures, percentages by volume of carbon dioxide and oxygen, and partial pressures of carbon dioxide and oxygen calculated from the percentages within each desiccator sealed originally at 76.8 cm., 37.8 cm., and 12.2 cm. of pressure calculated initially and measured at the four removals in Run KK. The larger variations occurred in the desiccators which were examined toward the end of storage and were probably due to leakage.

Apparently there was greater production of carbon dioxide in desiccators under high vacuum than in desiccators under low vacuum, rather than just a greater rate of increase in percentage of carbon dioxide. However, in some cases, especially apparent in the desiccators sealed initially at 12.2 cm., the changees in total desiccator pressure were great enough to

TABLE 1

Pressure, percentage carbon dioxide and oxygen (vol.), and partial pressures of carbon dioxide and oxygen within each of ten desiccators ground lamb samples, containing five sealed initially at 75.5 cm. and five at 25.1 cm. of pressure. (Run HH)

Initial desiccator pressure (cm.)	Days in storage	Desiccator pressure (cm.)	% CO_2	% O_2	Partial pressure CO_2 (cm.)	Partial pressure O_2 (cm.)
75.5	0	75.5	0.3	20.7	0.2	15.6
	1	72.2	0.7	20.4	0.5	14.7
	3	72.7	0.8	20.1	0.6	14.6
	14	75.8	7.6	12.5	5.8	9.5
	17	74.6	12.2	7.7	9.1	5.7
25.1	0	25.1	0.3	20.7	0.1	5.2
	1	24.0	0.7	20.0	0.2	4.8
	3	25.9	0.6	19.5	0.2	4.1
	14	39.4	12.6	8.3	5.0	3.3
	17	69.5	14.3	5.9	9.9	4.1

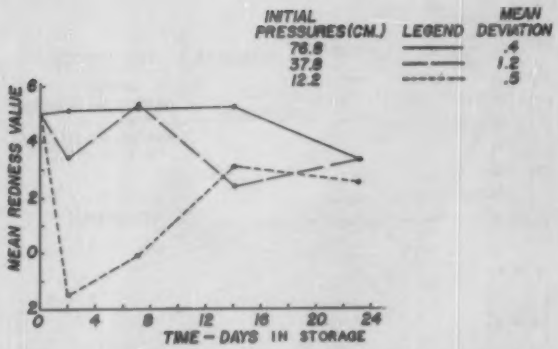

Figure 4. Redness changes of the top surfaces of ground pork lean samples stored initially at 76.8 cm., 37.8 cm., and 12.2 cm. pressures of air. (3 replicates). Run KK.

reverse the trends of change in partial pressures of carbon dioxide and oxygen even though, percentage-wise, the trends in change were consistent in all desiccators.

Mixtures of Air and Oxygen (Runs II, JJ, 3, and 4). Meat was stored in desiccators under varying partial pressures of air and oxygen while the total pressure was maintained at that of normal atmosphere. Gas analysis was made of the atmosphere within each desiccator when it was removed for examination. The partial pressures of carbon dioxide and oxygen were calculated and the redness values of the meat were determined.

Ground lamb samples were stored in desiccators among which the partial pressures of oxygen were varied while maintaining the total pressure within the range 74.0 to 77.0 cm. by means of supplementing nitrogen and carbon dioxide in their normal air proportions. Figures 5, 6, and 7 show the redness changes of ground lamb stored under oxygen partial pressures which, initially, were 15.8 cm., 25.5 cm., and 35.6 cm. respectively, in Run II. Figures 8, 9, and 10 disclose the redness changes of ground lamb stored under oxygen partial pressures which, initially, were 15.5 cm., 25.2 cm., and 35.7 cm., respectively, in Run JJ. The degree of redness return varied inversely as the initial partial pressures of oxygen in the desiccators.

It is of interest to note that if examinations in Run II had been made on the same days as in Run JJ, possibly the patterns of redness changes would have been nearly identical in the two runs. There may have been a peak in redness at 7 days in Run II as in Run JJ that was missed because there was no examination in Run II at that time. Lines AD, BE, and CF in Figures 8, 9, and 10 reveal what it is assumed that the curves for Run JJ would have been if the examination on the 7th day had been omitted and an examination on the 11th day had been made.

Tables 3 and 4 show ratios calculated from data on color ratings weighted on the 12-day basis (see section II-A of the color studies, FOOD TECHNOL., 11[10] 1957) of samples stored in desiccators under reduced atmospheric pressure or under two "stepped-up" pressures of oxygen in normal atmospheric pressure. The ratios were taken to the ratings of samples stored in air of normal composition at atmospheric pressure in Runs GG, HH, II, and JJ. In Run II, raising the initial oxygen pressure from 25.5 cm. to 35.6 cm. had little effect on the total weighted redness values, while in Run JJ, which was conducted identically to Run II, the higher oxygen pressure (35.7 cm.) was accompanied by a greater improvement in rating for redness than was the lower pressure (25.2).

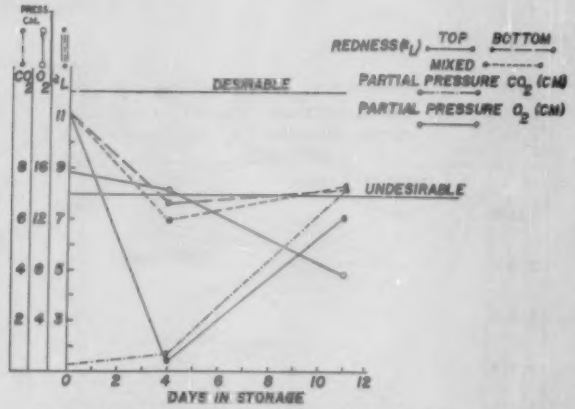

Figure 5. Changes of redness value and of oxygen and carbon dioxide pressures of samples during storage. (Ground lamb, stored initially under 15.8 cm. of oxygen). Run II.

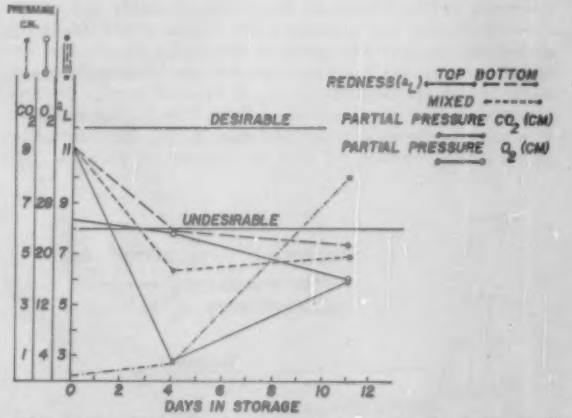

Figure 6. Changes of redness value and of oxygen and carbon dioxide pressures of samples during storage. (Ground lamb, stored initially under 25.5 cm. of oxygen). Run II.

In Run 3, also, oxygen was used to bring the desiccators back to atmospheric pressure after evacuating a part of the air. Table 5 shows the partial pressures of carbon dioxide, oxygen, and nitrogen in the desiccators as calculated at 0 days and the partial pressures of these gases determined at removal (3 days) in Lots A and B of this run. There were 5 desic-

TABLE 2

Pressure, percentage carbon dioxide and oxygen (vol.), and partial pressure of carbon dioxide and oxygen within each desiccator sealed initially at 76.8 cm., 37.8 cm., and 12.2 cm. of pressure. (Run KK). (ground pork)

Initial desiccator pressure (cm.)	Days in storage	Desiccator pressure (cm.)	% CO_2	% O_2	Partial pressure CO_2 (cm.)	Partial pressure O_2 (cm.)
76.8	0	76.8	0.1	20.7	0.1	15.9
	2	75.4	0.8	20.2	0.6	15.2
	7	75.9	1.2	20.1	0.9	15.2
	14	75.8	9.2	12.1	7.0	8.8
	23	74.9	14.8	4.9	11.1	3.6
37.8	0	37.8	0.1	20.7	0.0	7.8
	2	43.4	1.0	20.4	0.4	8.9
	7	37.6	5.0	15.8	1.9	6.0
	14	73.2	15.7	3.9	11.5	2.9
	23	72.0	19.5	0.5	14.1	0.3
12.2	0	12.2	0.1	20.7	0.0	2.5
	2	15.6	3.3	18.9	0.5	2.9
	7	12.8	4.3	17.3	0.5	2.2
	14	75.0	13.7	6.7	10.3	5.0
	23	35.0	21.3	0.7	7.5	0.3

cators in each lot. The distinction between lots A and B was that they were initiated on different days. The difference between the initial pressures and those at removal were not as great in this run as in Run 1, because, in Run 3, oxygen was added to the desiccators while the desiccators were at 40° F. Oxygen was added until the desiccators were almost at atmospheric pressure, then after 10 minutes at about 40° F., the pressure was adjusted to atmospheric pressure and the desiccators stored at 40° F. to 43° F.

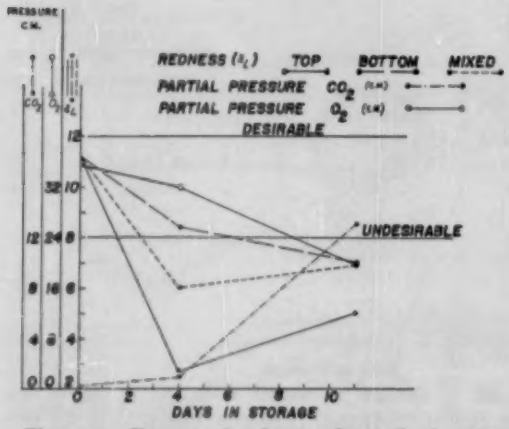

Figure 7. Changes of redness value and of oxygen and carbon dioxide pressures of samples during storage. (Ground lamb, stored initially under 35.6 cm. of oxygen). Run II.

The pressures at removal were plotted against the "k" values of the meat. Figure 11 shows, for Run 3, the "k" values obtained for the top surfaces of ground beef samples plotted against the partial pressures of CO_2, N_2, and O_2 in the atmospheres surrounding the meat. Partial pressures of N_2 and O_2, when plotted against the "k" values gave curves of the same shape, but reversed with respect to each other in orientation. The curve of CO_2 differed in shape from the other two curves, probably because the amount of CO_2 was so small. In Lot A an increase in initial O_2 pressure from 15.6 cm. to 24.0 cm. caused an accelerated decrease in redness. A progressive increase in redness retention during 3 days of storage occurred as initial oxygen pressures varied from 24.0 to 65.6 cm. Such a reversal in trend was also observed in Lot B, although at an O_2 partial pressure of 42.8 cm. instead of 24.0 cm. The

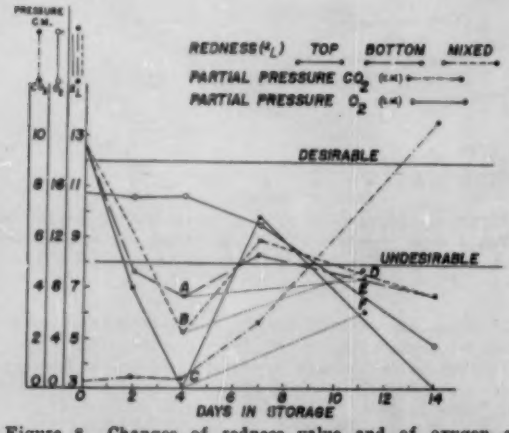

Figure 8. Changes of redness value and of oxygen and carbon dioxide pressures of samples during storage. (Ground lamb, stored initially under 15.5 cm. of oxygen). Run JJ.

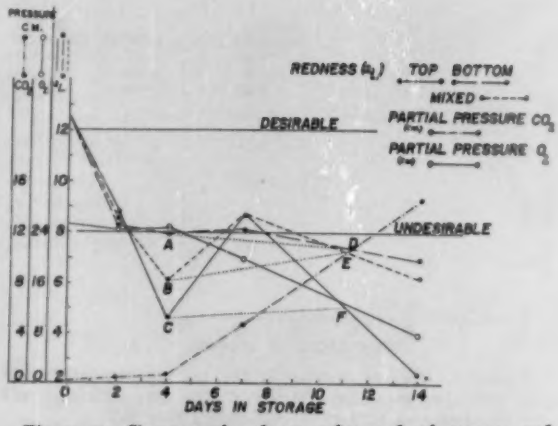

Figure 9. Changes of redness value and of oxygen and carbon dioxide pressures of samples during storage. (Ground lamb, stored initially under 25.2 cm. of oxygen). Run JJ.

bottom surfaces of the ground beef samples usually darkened more rapidly at higher O_2 partial pressures.

Figure 12 shows the results obtained under the same conditions for ground cured ham. There was considerable difference between Lots A and B in the effect of higher initial O_2 partial pressures on the redness.

Cured ham in desiccators. Cured ham presented quite a different picture from that obtained with fresh meat. Storage of the cured ham under vacuum resulted in improved color retention to a degree which was roughly proportional to the vacuum. This seems to be in accordance with the literature on the subject. There were indications of a return in redness after an initial decrease in redness in cured ham sealed under vacuum in film 15 (cellophane pliofilm laminate, pliofilm inside) stored in the light. Samples sealed in film 15 and stored in the dark usually decreased slowly in redness.

Figure 13 shows the effect on the top surfaces of ground beef and ground cured ham samples stored for 14 days at 39° F. to 42° F. in Run 4 at initial O_2 pressures of 15.8 cm.,

TABLE 3

Ratios of Weighted Color Ratings of Samples Stored in Air at Sub-Atmospheric Pressures to the Ratings of Samples Stored in Air at Atmospheric Pressure in the Same Runs (12-Day Basis)

Run	Type of meat	Desiccator pressure (cm.) of air	Weighting system Short	Long
GG	Ground pork	51.0	.93	.92
HH	Ground lamb	25.1	.86	.89
KK	Ground pork	37.8	.88	.91
		12.2	.49	.49
	Cuts of pork	37.8	.87	.99
		12.2	.71	.75

TABLE 4

Ratios of Weighted Color Ratings of Samples Stored in Mixtures of Air and Oxygen at Atmospheric Pressure to the Ratings of Samples Stored in Air at Atmospheric Pressure in the Same Runs (12-Day Basis)

Run	Type of meat	Desiccator pressure (cm.) of oxygen	Weighting system Short	Long
II	Ground lamb	25.5	1.03	1.03
		35.6	1.02	1.01
JJ	Ground lamb	25.2	1.06	1.03
		35.7	1.12	1.10

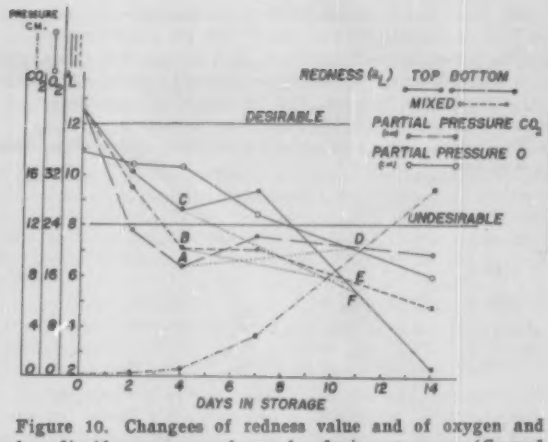

Figure 10. Changees of redness value and of oxygen and carbon dioxide pressures of samples during storage. (Ground lamb, stored initially under 35.7 cm. of oxygen). Run JJ.

35.0 cm., and 69.6 cm. At 8 days, samples in all 3 desiccators were slimy on the surface and sticky when kneaded, although samples stored at 15.8 cm. were higher in redness than the other two samples. This figure also shows the deleterious effect of increased oxygen pressures on the redness of the top surfacees of cured ham.

In two runs (not shown) fresh lamb was stored under similar conditions of oxygen pressure. In one run the rate of initial redness loss was not retarded by increasing the oxygen partial pressure, while in the second run the rate of redness loss was retarded at higher oxygen partial pressures. The inital pressures of oxygen were 15.5 cm., 25.2 cm., and 35.7 cm. At the 2- and 4-day removals, redness was retained in direct proportion to the initial oxygen partial pressures, although all samples decreased in redness. Between 4 and 7 days all samples increased to about the same redness value. Between 7 and 14 days all samples decreased in redness.

TABLE 5

Calculated initial pressures and pressures at removal (3 days) of CO_2, O_2, and N_2 within the desiccators containing meat samples in Run 3. (Ground Beef and Ground Cured Ham)

Lot	Desiccator	Calculated initial pressures (cm.)			Pressures at removal (cm.)		
		CO_2	O_2	N_2	CO_2	O_2	N_2
A	1	0.3	15.7	60.5	0.3	15.6	60.5
A	2	0.2	25.0	51.2	0.4	24.0	50.6
A	3	0.2	36.6	40.0	0.5	35.9	39.6
A	4	0.1	51.4	24.9	0.4	49.1	24.4
A	5	0.9	68.4	8.0	0.4	65.6	8.8
B	1	0.1	21.0	55.7	0.3	20.7	54.8
B	2	0.1	33.3	43.5	0.4	32.5	43.1
B	3	0.1	44.8	32.0	0.4	42.8	31.6
B	4	0.0	59.1	17.7	0.4	57.3	18.0
B	5	0.0	73.9	3.0	0.3	71.6	3.7

Table 6 shows the total pressures, percentages by volume of carbon dioxide, oxygen, and nitrogen, and partial pressures of these gases calculated from the percentages within each desiccator sealed at atmospheric pressure under varying partial pressures of oxygen in Run 4.

Special Treatment of Cured Ham. A special study was made to determine the effects of light and of differences in pressure of air surrounding pieces of cured ham, sealed in cellophane-pliofilm laminate containers (film 15) upon the color of the ham. Non-tenderized hams were obtained from a local butcher. Hams processed by a large company were used since it was believed that the conditions of cure would be well controlled and the variation from ham to ham would be minimized.

The hams were boned in the laboratory, except for one run, in order to try to minimize the bacterial contamination. After being boned, the hams were divided into cross-sectional cuts, perpendicular to the bone, approximately ¾ of an inch thick. From these slices, 3 in. x 4 in. samples were cut so that each sample was predominantly one muscle with a minimum of fat. Care was taken to keep the exposure to light at a minimum. Samples were placed in covered pans as soon as they were trimmed. When all samples had been cut from a ham, they were placed in a dark refrigerator while the next ham was prepared.

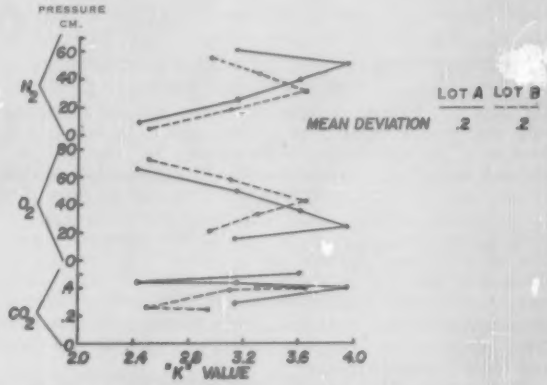

Figure 11. Relationship between "k" values of the top surface of ground beef and the partial pressure (cm.) of carbon dioxide, oxygen, and nitrogen at removal. (4 replicates). Run 3. ("k" value = mean daily decrease in redness for the first 3 days of storage).

After all samples had been prepared, they were placed in a churn and rotated at 15-20 r.p.m. for 5 minutes to ensure a balanced distribution of microorganisms on the surfaces of the samples, and to attain a uniform surface color.

Two series of samples were packaged in each run.

The first series consisted of duplicate samples for each treatment. The color of these samples was measured daily through the transparent film, and then returned to the storage cabinet. This series was included to minimize sample to sample variation.

The second series consisted of 12 samples for each treatment. Duplicate samples for each treatment were removed

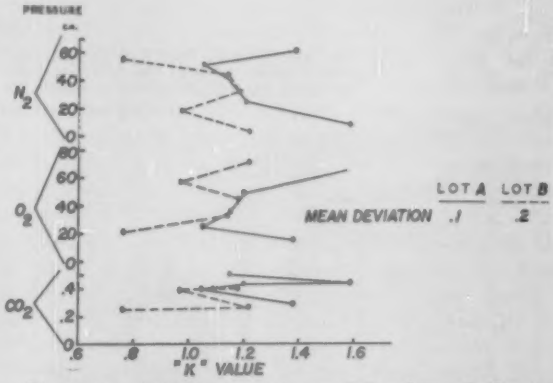

Figure 12. Relationship between "k" values of the top surface of ground cured ham samples and the partial pressure (cm.) of carbon dioxide, oxygen, and nitrogen at removal. (4 replicates). Run 3. ("k" value = mean daily decrease in redness for first 3 days of storage).

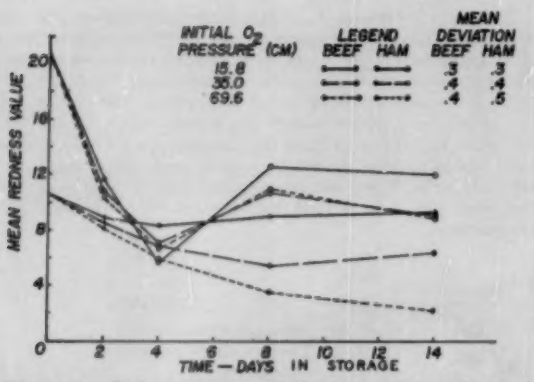

Figure 13. Redness changes of the top surfaces of ground beef and ground cured ham samples stored at atmospheric pressure in atmospheres containing initially 15.8 cm., 35.0 cm., and 69.6 cm. partial pressure of oxygen. (4 replicates). Run 4.

from storage on 1, 2, 4, 7, 9, and 12 days after packaging. The color on these samples was measured both through the transparent film and on the unpackaged sample. The sample was discarded after color measurementst were made. This type of sample was used because the color of cured ham samples faded while the color was being measured by the Hunter Color and Color-Difference Meter.

A regression curve, based on data indicating the change of color which cured ham suffered while under exposure to light in the Hunter Meter is shown in Figure 14. There was no significant difference between the rate of change in color of unpackaged samples and that of samples sealed in cellophane-pliofilm pouches under atmospheric pressure. The equation for the curve is

$$\overline{Y}_x = 0.9953 - 0.000657(X - 95.2581)$$

Where $\overline{Y}_x$ is the log of the a_L value and X is time in seconds.

To produce these data, 8 color measurements were made on each of 6 samples and 7 color measurements were made on each of 2 samples. All of the samples were originally sealed in cellophane-pliofilm pouches under atmospheric pressure. The initial color measurement on each sample was made while the sample was still in the pouch. All subsequent readings were made after the sample had been removed from the pouch. The average value for the error due to the film cover upon the indicated color of the ham was 0.19 a_L unit, with a standard deviation of 0.663. This low value shows that the film cover had little influence upon the indicated color of cured ham.

All color measurements in this experiment were corrected for time of exposure in accordance with the above equation.

The following treatments were used in each run on samples packaged and sealed in cellophane-pliofilm laminate containers: (a) atmospheric pressure, (b) 10 inches of vacuum, (c) 20 inches of vacuum, and (d) 29 inches of vacuum.

The control samples were sealed under 29 inches of vacuum in film 15.

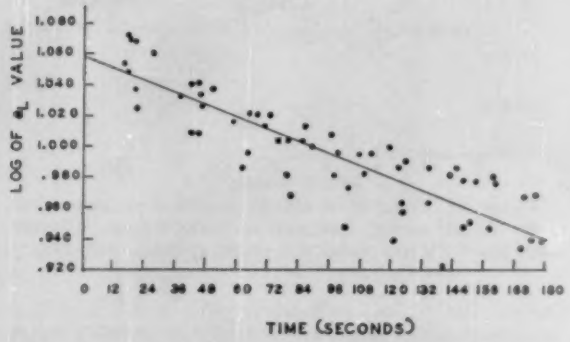

Figure 14. Rate of change of a_L value for samples of cured ham while being exposed on the Hunter Color and Color-Difference Meter. Samples originally sealed in cellophane-pliofilm pouches under atmospheric pressure.

In 4 runs because of space limitations each treatment was replicated only 3 times.

The desired vacuum was attained in the cellophane-pliofilm laminate containers by placing the sample in the sealing chamber evacuating to 29 inches of vacuum, holding this vacuum for 10 seconds, and then permitting air to re-enter the chamber through a needle valve until the desired pressure was reached. The valve was then closed and the package sealed.

The samples for each run were stored in a closed, lighted, refrigerated cabinet. The length of storage was 12 days, since no significant color changes occur in samples after this period.

The temperature of the refrigerated cabinet varied between 32° and 42° F. throughout the experimental period. There was some temperature variation within the cabinet.

The light source was two banks of 15-watt Cool White Westinghouse Fluorescent lamps. Outside light was excluded. The intensity of light had a mean of 115 foot candles with a standard deviation of 16.2. Light intensity was measured

TABLE 6

Pressure, percentage carbon dioxide, oxygen, and nitrogen (vol.), and partial pressure of carbon dioxide, oxygen, and nitrogen within each desiccator sealed at atmospheric pressure in which the initial partial pressures of oxygen were 15.8 cm., 35.0 cm., and 69.6 cm. (Ground Beef and Ground Cured Ham) (Run 4)

Initial oxygen partial pressure (cm.)	Days in storage	Desiccator pressure (cm.)	% Carbon dioxide	% Oxygen	% Nitrogen	Partial pressure carbon dioxide (cm.)	Partial pressure oxygen (cm.)	Partial pressure nitrogen (cm.)
15.8	0	76.4	0.2	20.7	79.1	0.1	15.8	60.5
	2	75.6	0.5	20.4	79.2	0.3	15.4	59.9
	4	75.4	3.1	17.3	79.7	2.3	13.0	60.1
	8	74.1	17.1	1.5	81.4	12.7	1.1	60.3
	14	77.2	18.8	0.3	81.0	14.5	0.2	62.5
35.0	0	76.2	0.1	45.8	54.1	0.1	35.0	41.3
	2	74.8	0.6	45.1	54.3	0.4	33.8	40.6
	4	75.8	6.2	39.1	54.7	4.7	29.6	41.5
	8	72.6	15.5	28.0	56.5	11.3	20.3	41.0
	14	73.8	23.5	18.9	57.6	17.4	14.0	42.5
69.6	0	76.4	0.0	91.1	8.9	0.0	69.6	6.8
	2	76.0	0.6	89.4	10.0	0.5	67.9	7.6
	4	75.2	2.9	86.9	10.2	2.2	65.4	7.7
	8	74.2	15.9	73.1	11.1	11.8	54.2	8.2
	14	70.6	33.9	54.1	12.0	24.0	38.2	8.5

by a Weston light meter at the level at which the samples were stored.

The samples stored in the light were randomly distributed throughout the storage area of the cabinet. The control samples were stored in the dark. To exclude light from the control samples they were wrapped in a light resistant paper, placed in a stainless steel pan, and covered by a sheet of aluminum.

Cured ham in films. Figure 15 shows the average a_L values for one series of samples cured ham in which the color measurements were made when the meat was covered with the film. The color of these samples was measured daily. Only the control samples maintained acceptable color throughout the storage period.

Significant differences were found in the rates of change of color for different series of samples sealed under atmospheric pressure. If all hams were of the "stable" type, the shelf life of prepackaged cured ham would be longer.

A characteristic of the "stable" samples was a darker color than that normally associated with cured meat. The L reading on the Hunter meter was lower than normal, indicating that less light was reflected from the surface of such a sample.

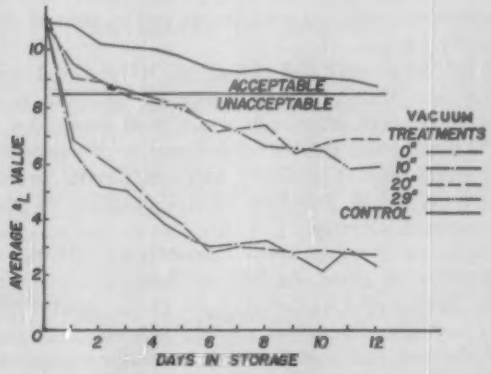

Figure 15. Average a_L values for cured ham samples of series 1, in which color measurements were made when the meat was covered with the film.

The origin and nature of this more stable type of pigment are not known. The phenomenon seemed to occur primarily in large hams, 15 to 18 pounds; therefore, age may be a causative factor.

The slope of the regression curve showing the rate of change of color of samples sealed under 29 inches of vacuum, when exposed to the light in the Hunter Color Meter, differed significantly from that of similar samples sealed under atmospheric pressure. The rate of discoloration was lower with samples sealed under 29 inches of vacuum. Correlation may exist between the rate of color change of a sample during its exposure on the Hunter meter and the stability of the pigment or the expected storage life of the sample.

In some samples an abnormal type of discoloration occurred. Instead of losing color over the entire surface of the sample, only the periphery of the sample lost redness, while the center section of the sample retained a good degree of redness. It was postulated that the concentration of oxygen diffusing into the packages was greater around the periphery of the sample than in other portions of the package, since vacuum caused the film to adhere to the surface of the sample away from the periphery. Oxygen on the surface of the meat was probably used up in fulfilling the biological oxygen demands of the microorganisms, whereas around the periphery the supply of oxygen in the interstices between the film and the meat was replenished and oxidizing conditions were established. It has been found that the rate of discoloration varies directly with the proportion of the oxygen present *(2)*.

DISCUSSION

Storage vacuum. Increasing the storage vacuum, while maintaining a constant temperature (40° F.) caused an increased rate of initial darkening of fresh meat, as might be expected from present knowledge of the effect of vacuum on the oxyhemoglobin dissociation curve and the rate of methemoglobin formation. Increasing the storage vacuum also shortened the time required for completion of the color change cycle, which includes a return of red color following its initial disappearance. No present knowledge seems to explain this reaction completely. The compound or compounds responsible for the red color appearing after initial darkening is not known, although evidence presented elsewhere in these studies on color indicates that a reduction of metmyoglobin to myoglobin is followed by formation of oxymyoglobin upon exposure to air. Storage under vacuum appears to be necessary for the return of redness after initial darkening and high storage temperature and/or high vacuum accelerate this return. When samples were stored at atmospheric pressure, an increase in storage temperature increased the rate of initial darkening, but only in rare instances was there a substantial return of redness to the meat.

The samples stored in desiccators under 28 cm. of air pressure (19 inches of vacuum), in general underwent the same color changes as samples sealed under 27 inches to 28 inches of vacuum in cans. The latter cans usually had about 24 inches of vacuum as measured by a puncture gauge.

The development of redness in meat stored under high vacuum is contrary to what might be expected from a review of the literature. Investigators are in agreement on the fact that decreased oxygen tensions favor the formation of methemoglobin and therefore discolorations. This is verified by results presented in this paper with respect to the initial discoloration. However, prior to 1950, when a subsequent return of redness of meat held under vacuum was discovered in this investigation, no mention of this phenomenon was found in the literature. It is possible that due to the detrimental effect on the initial color change caused by storage under vacuum, investigators have directed their attention to other methods of retaining the red color of meat, such as storage in packages having high oxygen permeability to maintain the hemoglobin in the "oxygenated" state. Under these conditions, the redness is maintained for 1 or 2 days, but on continued storage, discoloration becomes objectionable.

Oxygen. When the mean daily decrease in redness of fresh beef and cured ham samples for the first 3 days of storage ("k" value) was plotted against the initial partial pressures of CO_2, O_2, and N_2 in atmospheres in which the O_2 pressures had been varied from 15.6 cm. to 71.6 cm., some erratic relationships with changes in redness occurred. Both beef and ham decreased in redness during the first 4 days of the storage period regardless of the percentage of oxygen. An increase in the initial O_2 con-

tent of the gas mixture apparently retarded the rate of redness loss in beef during the early part of the storage period, and also retarded the rate of return to redness during the later part of the storage period.

In 4 experiments in which the partial pressure of oxygen was increased above the normal 16 cm. higher initial pressures of O_2 had little effect on the retention of redness in two of the experiments. Improved redness retention was found in the other two experiments.

It was noted that even at partial pressures of oxygen as high as 36 cm., the meat still lost redness, although at a somewhat lower rate than at lower partial pressures of oxygen. In oxygen pressures far above 20 mm., the partial pressure of oxygen below which reports in the literature state that oxyhemoglobin rapidly dissociates at 0° C., meat still loses redness at a comparatively high rate (see Figures 5 through 10). This indicates that the presence of free oxygen cannot in itself be responsible for the maintenance of color. Based on the present knowledge of heme pigments, it is assumed that a loss of redness in meat, regardless of the quantity of oxygen present, involves a decrease in oxyhemoglobin content. Perhaps microorganisms are capable of removing the oxyhemoglobin even though the atmosphere surrounding the meat contains considerably more oxygen than that normally present in air. In other words, higher partial pressures of oxygen may decrease the rate, but not necessarily the extent, of initial discoloration; or else, the presence of oxygen may decrease the rate of reaction only under certain conditions.

SUMMARY

Temperature and Vacuum. When fresh meat was stored under a vacuum of 20 inches or more, both the initial loss of redness and the return of redness were more rapid than in meat stored under a vacuum of less than 20 inches. Both increasing the vacuum while maintaining a constant storage temperature and increasing the storage temperature while maintaining a constant vacuum increased the rate of initial darkening and shortened the time for the subsequent return of redness. Vacuum appears to be necessary for the return of redness, but not for the initial darkening.

The change in color from grey to red, which occurred in samples stored under vacuum, is apparently reversible. A change can be produced toward either greyness or redness, depending on the absence or presence of high vacuum, respectively.

Air and Oxygen. In Runs 2, 4, and 6, in which one of the atmospheric gases (oxygen) was increased at the expense of the other gases, one storage condition was air at atmospheric pressure. The same types of color changes were expected in the three runs. In all three runs, the beef samples decreased in redness between 0 and 4 days; in Runs 2 and 6 the samples remained constant in redness between 4 and 8 days, and increased slightly in redness between 8 and 14 days; in Run 4, the samples increased in redness between 4 and 8 days, and remained constant in redness thereafter.

The cured ham samples stored in air in Runs 4 and 6 decreased slightly in redness for the first four days of storage and lost very little color for the remainder of the storage period. Samples in Run 2 decreased more in redness during the first four days of storage than samples in the other two runs, but gradually increased in redness between 4 and 14 days.

These inconsistencies in color changes of samples stored under the same conditions in different experiments indicate that various concomitant conditions may influence color changes.

The rate of initial discoloration of fresh meat was less in those atmospheres containing initially higher partial pressures of oxygen. With cured ham less discoloration resulted with lower initial partial pressures of oxygen.

When fresh beef and cured ham were stored under about one atmosphere of pressure, and the initial partial pressure of oxygen was varied from 15.6 cm. to 71.6 cm., the rate of discoloration of fresh beef, in general, varied inversely with the partial pressure of oxygen while the rate of discoloration of cured ham varied directly.

Light vs. Vacuum with Cured Ham. Of the two factors which affect the rate of discoloration of cured ham, Bressler* found that light has a greater effect than vacuum. Samples sealed in film 15 (cellophane-pliofilm laminate) in air under atmospheric pressure can be stored for several weeks in a dark refrigerator and maintain an attractive color. If these samples were stored in a lighted refrigerated cabinet, they would be discolored within 46 hours *(1)*.

In spite of a high vacuum, samples packaged in film 15 under 29 inches of vacuum and stored in the light maintained an attractive color for only the first two days of storage, but the control samples, sealed under 29 inches of vacuum and stored in the dark, maintained an attractive color throughout the storage period, as shown in Figure 15.

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2. Urbain, W. H., and Jensen, L. B. The heme pigments of cured meats. I. Preparation of nitric oxide hemoglobin and the stability of the compound. *Food Research*, 5, 593 (1940).

*Color changes during storage of prepackaged cured ham sealed in cellophane-pliofilm laminate containers while surrounded by air at various pressures. Thesis by Lawrence Bressler, Rutgers University, May 1954.

Time-Temperature Tolerance of Frozen Foods

X. Retail Packs of Frozen Red Raspberries

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(Manuscript received June 17, 1957)

THE BACKGROUND AND OBJECTIVES of the time-temperature-tolerance project under way at this Laboratory have been discussed by Van Arsdel in the first article of this series *(6)*. Results on commercially packed frozen peaches and strawberries have been reported *(1,2)*. This paper reports the effect of various time-temperature experiences on chemical, physical, and organoleptic changes in commercially packed frozen raspberries.

MATERIALS AND METHODS

All the frozen raspberries used were purchased from commercial processing plants in Oregon and Washington. Sampling was limited to these states because they are the major producers of frozen raspberries. Samples were obtained during 4 seasons and represented the major commercial freezing varieties in these areas. Generally, berries were washed, sorted, and packed into 12-oz. composite cartons in the ratio of 3 parts berries to one part of 50% sucrose sirup. After packing, samples were frozen in air-blast freezers at 0 to –20° F. The frozen material was shipped to the laboratory under dry ice refrigeration to maintain temperatures below 0° F.

During this 4-year period 16 lots of fruit ranging from 500 to 900 packages each were obtained. Each lot was selected from a fairly uniform block of raw material and was chosen to represent as nearly as possible a typical commercial pack. Details of handling and storing the fruit at the laboratory were identical with those described for frozen strawberries *(2)*. Briefly, this method involved holding all control samples at –20° F. and exposure of experimental samples to a variety of time-temperature conditions including steady temperatures (0° to 30°), regularly fluctuating temperatures, simulated transportation and distribution patterns, and other time-temperature sequences.

Organoleptic evaluation. Color and flavor changes were determined by the triangle test in exactly the same manner as described in the paper on strawberries *(2)*. Ten to 15 trained judges were used for both color and flavor measurements and each test was replicated 2 or 3 times, giving a total of 20 to 30 judgments. In this paper organoleptic results are considered significant or "real" only if 70% or more correct judgments were obtained when experimental and control samples were compared by triangle test. This figure, which obviously represents a highly significant difference, was selected for better reproducibility and is discussed elsewhere *(3)*.

In addition to the triangle, a consumer-type preference test was conducted with 42 untrained laboratory employees. Finally, several samples were submitted to groups of quality-control experts for their opinions with regard to probable consumer reaction.

Analytical. Drained weights were determined by thawing the samples at room temperature in the draft of an electric fan for 2 hours and draining on an 8-mesh screen for 2 minutes. Ascorbic acid was determined on the drained berries and drained juice by the method of Loeffler and Ponting *(5)*. The total acidity of the drained berries and juice was determined by electrometric titration to a pH value of 8.0 ± .05 with a pH meter and 0.1*N* NaOH. The determination was made on 100 g. of a uniform mixture consisting of 50 g. of homogenized berries and 500 ml. of water. Homogenization of the drained berries and blending homogenate with water was accomplished with a Waring blender. For the juice, 50 g. were diluted to 500 ml. with distilled water and a 100-ml. aliquot was titrated. All total acid measurements were expressed as anhydrous citric acid.

Color of the drained juice and berries was determined colorimetrically by measuring the transmittance of diluted solutions of the juice and berry extracts at 515 mμ. Details of this procedure are reported elsewhere *(4)*.

Soluble solids were determined in samples of drained juice and homogenized berries by refractometer and expressed as percent sucrose.

RESULTS

Comparisons at a steady temperature of 20° F. Since frozen raspberries are considered relatively more stable than most other fruits, it is somewhat surprising that over 90% of the lots tested showed highly significant flavor changes within 2 weeks at 20° F. After 1, 2, and 3 weeks at 20° F. the number of lots which showed significant flavor differences from –20° F. controls were 4, 11, and 1, respectively. Repeated experience with frozen sirup-packed raspberries stored at 20° F. indicated that the principal reason for this apparent ease of discrimination between stored and control samples was a change in the sugar-acid balance of berries and sirup rather than development of objectionable flavors. Table 1 shows a gradual increase in total acid of the sirup with a decrease in acidity of the drained berries. After 2 to 3 weeks at 20° F. the acidity of the sirup had increased by approximately 2- to 3-fold. Obviously, an acid change of this magnitude would be expected to alter the overall flavor characteristics of the pack.

Table 2 shows that even after the berries were stored at 20° F. for 6 weeks and practically all the trained laboratory judges correctly identified the duplicate samples, preference was almost evenly divided between control and stored samples. If ease of selection were principally due to objectionable off flavors, it would be expected that the preferences would be predominantly in favor of the control. Since this is not the case, it appears that the observed changes were not objectionable, but actually preferable over the control to approximately half of the tasters used in these experiments.

In this connection it is interesting to note that in a paired comparison test using 42 untrained laboratory tasters, 48% preferred the control and 52% preferred the sample stored at 20° F. for 6 weeks. Two groups of industrial quality-control experts who were familiar with the range of quality which might result in consumer complaints graded 2 series of different samples stored at 20° F. for various times. Less than 10% of the judges in both groups (2 out of 30) indicated that samples held at 20° F. for as long as 7 weeks might result in consumer complaint. Over 70% of these experts were of the opinion that strawberries held at this temperature for 6 weeks would cause complaint. Thus it is clear that flavor changes readily occur at 20° F. but that many people may consider these changes (at least in the initial stages) an improvement rather than a detriment, and that from the standpoint of flavor, raspberries are much more stable than strawberries.

Comparisons at various steady temperatures. As pointed out in the section on methods, the organoleptic results on color and flavor are based on the time required for 70% correct judg-

[a] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

TABLE 1
Effect of storage at 20° F. on drained weight and total acid distribution between berries and sirup

Days at 20° F.	Total Acidity[1] in Drained Juice, %				Total Acidity[1] in Drained Fruit, %				Total Acid Ratio, Fruit/Juice				Drained Weight, %			
	Lots				Lots				Lots				Lots			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0	.42	.54	.52	.54	1.28	1.30	1.17	1.11	2.98	2.41	2.25	2.26	79	70	76	75
2	.67	.57	.63	.60	1.08	.90	1.03	1.01	1.61	1.58	1.64	1.69	75	67	74	73
5	.83	.70	.78	.75	.87	.82	.90	.86	1.05	1.17	1.27	1.15				
9	.98	.78	.85	.86	.82	.74	.85	.75	.84	.95	1.00	.87	74	66	73	73
16	1.05	.90	.96	.96	.79	.74	.80	.73	.75	.82	.83	.76	73	65	71	70
41	1.08	.89	1.00	.98	.72	.69	.79	.70	.67	.78	.79	.75	70	66	70	67
56	1.06	.92	1.00	1.00	.73	.64	.73	.65	.69	.70	.73	.65	68	64	70	68
77	1.04	.95	1.03	1.03	.70	.63	.72	.61	.67	.71	.69	.59	65	66	66	63

[1] Total acidity expressed as anhydrous citric acid.

ments and may not reflect the development of objectionable off flavor alone but certainly include changes due to sugar and acid diffusion between berries and sirup. Therefore it must be emphasized that while these are definitely recognizable changes, they do not necessarily represent flavor changes which would result in complaints from the consuming public as a whole.

The relation between time required for 70% correct flavor and color judgments and temperature is shown in Figure 1. Since this relation is logarithmic, the time required for this degree of color and flavor change varies exponentially with temperature. Therefore it is possible to predict the approximate time required for changes of this magnitude for any temperature within this range (0 to 30° F.). It is interesting to note that the time required for an increase of 5 color index units in the sirup *(4)* is practically the same as that required for 70% of the judges to segregate the duplicates correctly on the basis of color. This indicates an excellent correlation between visual observation of color change, flavor change, and the transfer of color from berries to sirup. It is also interesting to note that the rates of these changes are reduced by one-third to one-half for each 5 degrees that the temperature is reduced in the 0 to 30° F. range. The magnitude of this temperature effect is very similar to that found for strawberries *(2)*.

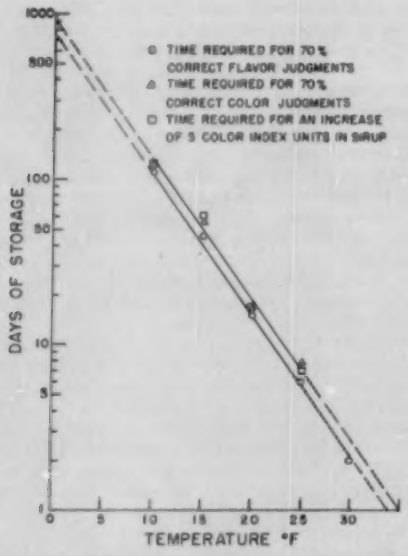

Figure 1. Relation between temperature and relative rates of color and flavor changes.

Color ratio. The significance of color transfer from berries to sirup has been discussed in the preceding paper *(4)*. Therefore the present discussion will be limited to the effect of time and temperature on color ratio, which is defined as the number obtained by dividing the color index of the berries by that of the sirup. Figure 2 shows that color ratio minus 1.0 varies exponentially with time at temperatures in the 10° to 30° F. range. The final ratios approach values in the neighborhood of 1.0, and the time required to reach this ratio also varies exponentially with temperature in the 20° to 30° F. range. Graphs such as those in Figure 3 may be used to estimate temperature history until the color ratio approaches 1.0. After this value is reached, there is little or no further change in ratio; therefore, color ration is no longer useful in estimating time-temperature exposure.

Total acid ratios and drained weight. In addition to color, the total acid ratio can be used as an indicator of temperature history. This merely involves determining the total acidity of the drained fruit and sirup. As shown in Table 1, the total acid ratio drops markedly within 1 to 2 weeks of storage at 20° F. and appears to level off at a value of approximately 0.5 to 0.7. It is interesting that the drained weight of the berries also gradually decreased during storage at this temperature to the extent of approximately 10%. At lower temperatures, no consistent trends of decreasing drained weights were observed and at higher temperatures the magnitude of the changes was approximately the same but they occurred much more rapidly.

TABLE 2
Effect of storage at 20° F. on flavor changes and judges' preference in sirup packed frozen raspberries

Weeks of Storage	% Correct Answers				% Who Preferred[1]							
					Control Sample				Stored Sample			
	Lot No.											
	1	2	3	4	1	2	3	4	1	2	3	4
1	46	58	40	70	45	40	60	50	55	60	40	50
2	57	70	95	90	25	37	37	50	75	63	63	50
4	79	81	100	100	42	38	50	55	58	62	50	45
6	96	87	90	95	52	40	47	55	48	60	53	45

[1] Of those judges who correctly identified duplicates.

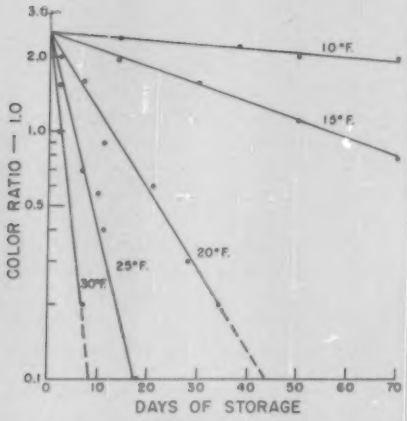

Figure 2. Effect of time and temperature on changes in color ratio.

Soluble solids distribution. Color and acid ratios change at temperatures as low as 10° F. and if stored long enough will gradually reach approximately the same values attained at higher temperatures in a much shorter time. On the other hand, Figure 3 shows that soluble solids of samples held at 20° F., or lower change very little with storage time. At 25° F. however, the solids content of the berries gradually increases while the sirup solids gradually decrease; hence, the soluble solids ratio increases very slowly. When the samples were stored at 30° F., an equilibrium value of 1.0 was obtained in a matter of 1 to 2 weeks. A soluble solids ratio of 1.0 is obtained only under complete thawing conditions and therefore serves as an excellent thaw index. Combined with color and acid ratios the soluble solids ratio can provide much useful information with regard to temperature history.

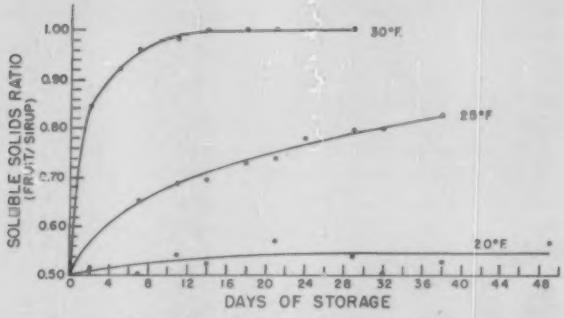

Figure 3. Effect of time and temperature on soluble solids distribution in frozen raspberries.

Ascorbic acid. The ascorbic acid changes in a representative lot of berries stored at various temperatures are shown in Figure 4. These values represent the amount of ascorbic acid found in fruit and sirup combined. It will be noted that there is very little loss in this constituent at 0° F. for one year but that it is rapidly oxidized at storage temperatures of 10° F. and above. However, it is also apparent that frozen sirup-packed raspberries contain only a minor amount of ascorbic acid. The original ascorbic acid content of the 16 lots ranged from 10 to 14 mg./100 g. and the oxidation rates were very similar to those shown in Figure 5. At 20° F. the initial rates of ascorbic acid loss for the 16 lots varied from 0.15 to 0.18 mg./100 g./day.

As in the case of color and total acidity, ascorbic acid migrates into the sirup during storage at temperatures of 10° F. and above. Thus the ascorbic acid ratio changes with time and temperature, but since this acid is readily oxidized, it yields ratios which are not as significant as those obtained by color, total acid, and soluble solids determinations.

Cumulative effect of storage at temperatures above 0° F. The combination of various storage periods at 10 and 20° F. both before and after storage at 0° F. for periods up to 18 months repeatedly showed that color and flavor changes are additive. Storage patterns and sequences were exactly the same as those described for strawberries *(2)* and the results on raspberries were very similar. For a more detailed discussion on cumulative effects the reader is referred to the paper on strawberries *(2)*. Figure 5 shows that holding raspberries at 0° F. for 3 months or 1 year does not cause any significant increase in rate of ascorbic acid oxidation when the samples are subsequently stored at 20° F. This was also true for color and

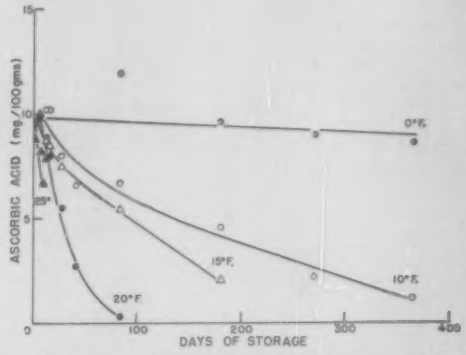

Figure 4. Effect of time and temperature on ascorbic acid content of fruit and sirup.

flavor changes. The samples held at 0° F. for one year in addition to 20° F. for various times are somewhat lower in ascorbic acid than those held constant at 20° F. This would be expected on the basis of an additive effect since 1 or 2 mg./100 g. are lost during storage at 0° F. for one year.

Effect of simulated distribution practices. The effect of various distribution patterns (Figure 6) on flavor changes is given in Table 3. As for strawberries it is apparent that if the maximum temperature during a distribution cycle of approximately one month's duration does not exceed 10° F. no significant flavor changes will occur. If the maximum temperature reaches 20° F., highly significant flavor changes develop during the distribution portion of the cycle (RD 20). At 30° F. definite changes are observed during the first segment of the

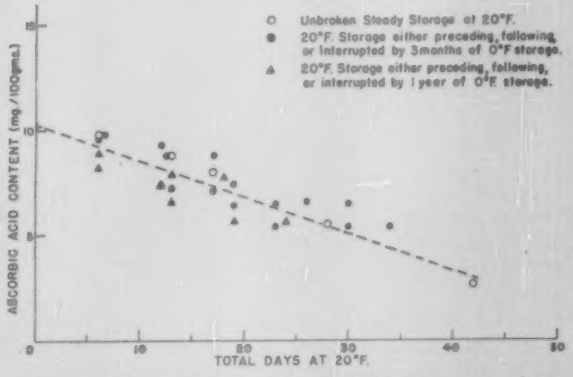
Unbroken Steady Storage at 20°F.
20°F. Storage either preceding, following, or interrupted by 3months of 0°F storage.
20°F. Storage either preceding, following, or interrupted by 1 year of 0°F storage.
ASCORBIC ACID CONTENT (mg./100gms.)
TOTAL DAYS AT 20°F.

Figure 5. Effect of prior storage at 0° F. on rate of ascorbic acid loss during subsequent storage at 20° F. Ascorbic acid was determined on total package contents.

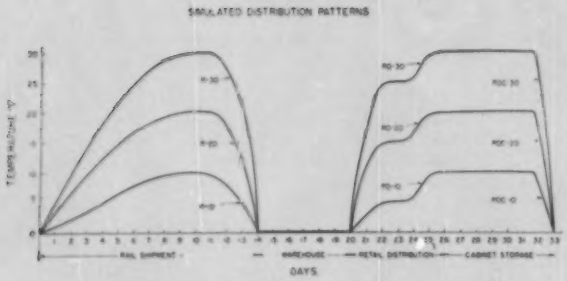

Figure 6. Time-temperature patterns with varying maximum temperatures.

distribution cycle (R30) and of course additional time-temperature experiences increase the magnitude of these changes. Changes in color ratio and ascorbic acid resulting from storage at 20° F. and under various distribution patterns are shown in Figures 7 and 8. Since changes at 10° F. are relatively slow, there is essentially no difference between the R10, RD10 and RDC10 sequences. At 20° F., however, the differences between RD20 and RDC20 sequences are roughly equal to the differences obtained during storage for on equal number of days at 20° F. This indicates again that changes under various combinations of time and temperature are essentially additive and do not cause increased rates of deterioration during subsequent exposure to high temperatures.

Effect of regular fluctuations. Samples were subjected to a large variety of regular sine wave fluctuations covering the range of −10° to +30° F. The patterns used for raspberries are identical to those described in the report on strawberries, and from the standpoint of effect of fluctuations *per se*, the results are also identical. Briefly, these results indicate that color and flavor changes which occurred under fluctuating temperature conditions were no different from those observed at equivalent steady temperatures. For a more detailed discussion of regular fluctuations, the reader is referred to the strawberry paper *(2)*.

TABLE 3

Effect of various simulated distribution patterns on flavor changes in frozen raspberries

Time-Temperature Pattern	Percent Correct Flavor Judgments	
	Lot A	*Lot B*
R10	46	41
R30	38	50
R30	75	77
RD10	23	42
RD20	77	84
RD30	85	84
RDC10	35	39
RDC20	87	84
RDC30	84	82

DISCUSSION

In Table 1 it is noted that the total acid concentration in the sirup gradually becomes higher than that in the drained berries during storage at 20° F. and thus yields an acid ratio of less than 1.0. Ascorbic-acid determinations on drained fruit and juice also yield ratios which are very similar to those obtained from total acid determinations. Under the same time-temperature conditions it has been repeatedly demonstrated that the color ratio remains fairly constant at a value in the neighborhood of 1.0. There is no clear-cut explanation for the fact that color ratios are somewhat higher than acid ratios under the same time-temperature conditions. Several possible explanations could be discussed at length, but since these are commercial samples, a number of variables such as fruit-to-sirup ratio, delay prior to freezing, freezing rate, etc., were not controlled with enough accuracy to make any explanation for these differences more than mere speculation. It is intended to study the problem further under controlled conditions and attempt to make better use of these ratios as time-temperature indicators.

SUMMARY AND CONCLUSIONS

Sixteen individual lots of commercially packed frozen raspberries have been obtained during 4 seasons and evaluated by means of subjective (color and flavor) and objective tests. Trained laboratory panels found highly significant flavor differences in approximately 90% of these lots within 2 weeks at 20° F. Preferences of the trained tasters and a large group of untrained laboratory tasters were, however, about evenly divided between −20° F. control and stored samples even after 6 weeks of storage at 20° F. Evidence is given to support the hypothesis that the prin-

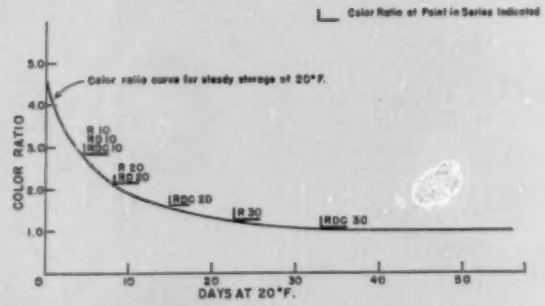

Figure 7. Comparison of color ratios obtained during various simulated distribution patterns with ratios at a steady temperature of 20° F.

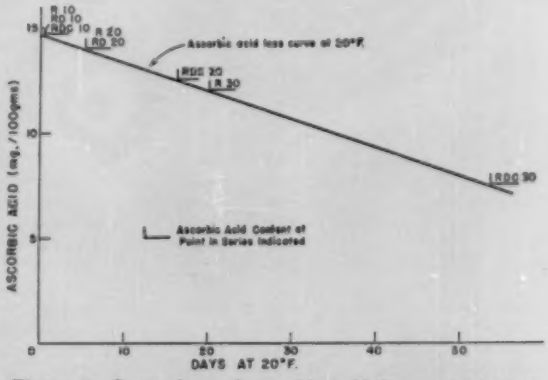

Figure 8. Comparison of ascorbic acid losses obtained in simulated distribution patterns with losses at a steady temperature of 20° F.

cipal reason for ease of selecting the stored from control samples is the migration of acidity from berries to sirup and not necessarily the development of objectionable flavor. Most of the frozen-food quality-control experts who examined samples held at 20° F. for various periods indicated that berries held at this temperature for 6 weeks would not result in consumer complaint. It must be emphasized, however, that other fruits such as peaches and strawberries would be seriously damaged under these conditions, and therefore it is of utmost importance that distribution practices be patterned to the requirements of the more sensitive commodities.

The time required for approximately the same degree of color and flavor change was found to vary exponentially with temperature over the 10 to 30° F. range, and the time required for an equivalent change was increased 2- to 3-fold for each 5° F. reduction in temperature.

Color and total acid ratios were found to give good indication of the temperature history of frozen raspberries. The soluble-solids ratio was found to be particularly useful as a thawing indicator.

Storage under various time-temperature conditions indicated that color, flavor, and ascorbic acid changes are additive and that the degree of change is the direct result of the sum of all the time-temperature experiences which the product may have encountered.

ACKNOWLEDGMENT

The cooperation and assistance of all the freezing plants where these commercial samples were obtained are gratefully acknowledged. The technical assistance of the following is also acknowledged: Doris G. Sweny, Margaret M. Stithem, A. M. Mylne, and N. J. Downes.

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Relation of Acidity to Variation in Browning of Canned Grapefruit Sections During Storage[a, b]

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During investigations of factors that affect the quality of commercial canned grapefruit sections, it was noted that there was can-to-can variation in the color of grapefruit sections that had been stored either for 6 to 12 months at temperatures existing in Florida warehouses or at 90° F. during experimental storage studies. Such color variation has been found among cans of commercial packs processed on a particular day, and also among packs prepared at different periods of the processing season. Huggart, Wenzel, and Moore *(3)* in studying the effect of storage temperature on the quality of canned grapefruit sections found that color, flavor, and firmness in stored sections were closely related and also that the quality of a given pack could be retained for one year at storage temperatures of 70° F. or lower. At higher storage temperatures some sections were found to darken faster than others, and other factors being equal, the lighter colored sections were found to be of better quality flavorwise. Can-to-can variation was noted also in total acidity, pH, Brix value, firmness, and flavor at the time of the initial examination of individual commercial packs. In an attempt to correlate the effect of date of packing on retention of quality, Huggart, Wenzel, Moore, and Barron *(4)* were able to show a relationship between the quality of grapefruit sections, after storage for 6 months at 90° F., and both the date of packing and total acid content. The color became darker and the firmness decreased in canned sections, obtained from a commercial plant, as the processing season progressed from November, 1953, to the middle of February, 1954. This confirmed the observations of many processors that better quality resulted in packs processed during the first portion of the packing season. However, a uniform pattern relating quality of stored sections to date of packing was not found in subsequent studies during 1954-55, when samples of canned grapefruit, processed at two other commercial plants, were obtained and examined after storage at 90° F. Thus, the possibility of factors affecting quality, other than date of packing, was indicated.

The browning of fruit products, including citrus juices, has been extensively investigated, and many good reviews of this subject have been published. As pointed out in some of these discussions *(2, 5, 7, 9)*, the color changes that occur during the storage of fruit products are related to the interaction of various constituents, such as sugars, amino acids, fruit acids, proteins, and ascorbic acid. Reactions involved in the darkening of these products may be either enzymatic or nonenzymatic.

Livingston, Pandit, Steinberg and Fellers *(6)* demonstrated that during storage, browning of a standard jelly (sucrose, pectin, citric acid gel) occurred faster in those samples having a greater citric acid concentration due to presumed chemical degradation of sugars and polymerization of some of the resulting breakdown products. The studies reported here were undertaken to determine if a similar relationship might exist between various properties of canned grapefruit sections after storage, especially between citric acid content and color.

EXPERIMENTAL PROCEDURE

Processing of commercial sections. The canned grapefruit sections used in this study were packed and processed in commercial plants, using procedures that have been described *(1, 8, 11)*.

"Warehouse" samples. The first lot of samples, selected from stacks in a commercial warehouse, had been packed on an early (November 1954) and on a late (March 1955) packing date. Each sample consisted of 2 cases of sections packed in 211 x 304 buffet cans. These particular sections were selected because can-to-can variation in color was known to exist in these products. They were brought to the laboratory after a warehouse storage period of 14 and 10 months, respectively, and 48 cans from each of the 2 packs were examined.

"Packing date" samples. The second lot of samples was obtained from a commercial plant at intervals of 2 weeks during a packing season (starting November 19, 1954, and running through February 11, 1955) to determine any possible effect of date of packing on product quality. Cases of sections selected were transferred to 32° F. storage after holding for 2 weeks at room temperature for "firming up"; then in February, samples were placed in 90° F. storage and finally 5 cans from each of the 7 packs were examined after 6 months.

"Acid level" samples. A third lot of samples, obtained from a commercial operation in January, 1956, consisted of 4 packs. In 3 of these the acid level was adjusted by the addition of either citric acid or sodium hydroxide. The fifth pack was taken from the production line after processing and used as a control. It had been hoped that the acidity of the grapefruit would be low enough so that the acidity in the canned product could be adjusted entirely by the addition of citric acid. But this was not found to be the case, and a solution of sodium hydroxide was used to lower the acidity of some of the packs. This addition of alkali was done to obtain preliminary information, even though the reaction of alkalies on sugars is well-known; if the concentration of hydroxyl ions is very low, a

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[b] Cooperative research of the Florida Citrus Commission and the Florida Citrus Experiment Station. Florida Agricultural Experiment Station Journal Series, No. 349.

molecular rearrangement of the sugar molecule results (Lobry de Bruyn transformation), whereas, in higher concentration of alkali, oxidation results. Total acid was raised to two levels by the addition of 2 ml. and 4 ml., respectively of 5.8 N citric acid to each can of a group and was also lowered to one level by the addition of 2 ml. of 5.8 N sodium hydroxide. Calculation indicated that the addition of 2 ml. of 5.8 N acid or alkali should change the acid level by 0.3%. As soon as the desired solution of acid or alkali was pipetted into the syrup of the selected, filled can, the sections were pressed gently to the bottom of the can several times to aid in dispersion of the solution throughout the syrup. The identified cans of a particular variation were returned immediately to the can line for closing and processing, and were later removed, cased by hand and transferred to a 90° F. storage room at the Station. After 6 months storage, 5 cans from each pack were examined.

Examination methods. The following examinations were made on each individual can of grapefruit sections selected from the above mentioned 3 lots of samples. Vacuum or pressure was determined by means of a dial type gauge. Gross headspace was measured in sixteenths of an inch. Drained weight of the sections was found by emptying the contents of the can onto a screen and allowing the sections to drain 2 minutes *(10)*. A portion of the drained syrup from each can was used for determination of total acidity, Brix value by refractometer, pH and ascorbic acid. Values for pH shown in the tables are arithmetical averages, since the differences in pH were so small that it did not seem necessary to average them, based on the hydrogen ion concentrations. Relative color of a can of segments within a pack was determined after placing the drained sections from each of the individual cans in separate 250 ml. beakers. A panel of 4 people at different times, one by one, separated the beakers of sections into 4 or 5 groups based upon color; number 1 being the lightest in color and number 4 or 5 the darkest. The numbers assigned by each of the panel members to each sample were averaged to arrive at a color rank for a given can of sections. This color rank indicates variation in browning, but is relative only within each group of samples since a browned reference sample for comparison was not available.

Calculation and tabulation of data. Data concerning all of the characteristics obtained from the examination of each individual can of grapefruit sections in the various packs were arranged in order from maximum to minimum values (Table 1). Data were then classified by placing the individual can values for a particular characteristic, such as total acid content or Brix value, in one of 3 groups corresponding to relatively high, medium, or low values. In the same manner, the data for individual cans were classified into 3 groups on the basis of each of the other characteristics measured. The values in each of these 3 groups were averaged and these averages are presented in Tables 2 and 3 for the "warehouse" and "packing date" samples. Average values for the color rank of each group, based upon the color of the grapefruit sections in the individual cans in each group for all of the characteristics, were also calculated and are shown in Tables 2 and 3. The results from the examination of the "acid level" packs are listed in Table 4.

TABLE 2

Relation of various characteristics of commercial canned grapefruit sections to browning during storage

"Warehouse" samples				"Packing date" samples	
November pack		March pack			
Total acid-%	Color rank [1]	Total acid-%	Color rank [1]	Total acid-%	Color rank [1]
1.05	3.1	1.27	3.1	1.20	4.3
0.94	2.6	1.15	2.8	1.06	3.7
0.80	2.0	1.03	2.7	0.90	2.4
pH	Color rank	pH	Color rank	pH	Color rank
3.54	2.4	3.35	2.8	3.47	2.8
3.47	2.5	3.31	3.0	3.39	3.5
3.38	2.8	3.28	2.9	3.31	4.0
Brix value	Color rank	Brix value	Color rank	Brix value	Color rank
19.7	2.7	18.2	2.2	18.7	4.0
18.7	2.5	17.3	2.9	17.4	3.3
17.8	2.5	16.3	2.5	16.5	3.1
Drained wt. grams	Color rank	Drained wt. grams	Color rank	Drained wt. grams	Color rank
162	2.8	158	3.1	....	....
152	2.6	149	2.9	....	....
138	2.3	140	2.8	....	....
Vacuum inches	Color rank	Vacuum inches	Color rank	Vacuum inches	Color rank
9.7	2.5	13.9	2.8	13.7	3.4
2.9	2.6	8.4	2.8	10.7	3.4
+2.5	2.6	+0.1	3.0	4.7	3.6
Headspace 1/16 in.	Color rank	Headspace 1/16 in.	Color rank	Headspace 1/16 in.	Color rank
6.0	2.6	6.4	2.8	6.8	3.5
4.9	2.4	5.5	2.8	5.5	3.6
3.0	2.7	4.5	3.0	4.6	3.3

[1] Color rank indicates the variation in browning, but is relative only within each group of samples since a browned reference sample for comparison was not available.

RESULTS AND DISCUSSION

Maximum and minimum values. Considerable variation from can-to-can was found in all of the packs of canned grapefruit sections examined. This is evi-

TABLE 1

Variations in characteristics of canned grapefruit sections

Samples	Color rank [1]	Total acid-%	pH	Brix value	Ascorbic acid mg./100 ml.	Drained wt. grams	Vacuum inches	Headspace 1/16 in.
"Warehouse"								
November pack								
Maximum	5	1.20	3.60	20.9	25.2	172	17	11
Minimum	1	0.73	3.30	17.0	12.5	112	+3	2
Difference	4	0.47	0.30	3.9	12.7	60	20	9
March pack								
Maximum	5	1.48	3.41	19.4	28.2	168	19	8
Minimum	2	0.96	3.25	15.5	19.3	129	6	3
Difference	3	0.52	0.16	3.9	8.9	39	13	5
"Packing date"								
Maximum	5	1.36	3.53	19.6	30.3	.....	16	8
Minimum	1	0.72	3.27	15.9	19.7	.....	+1	2
Difference	4	0.64	0.26	3.7	10.6	.....	17	5
"Acid level"								
Maximum	4	2.36	3.98	20.1	32.3	196	19	8
Minimum	1	0.80	2.89	16.3	19.5	118	2	3
Difference	3	1.56	1.09	3.8	12.8	78	17	5

[1] Color rank indicates the variation in browning, but is relative only within each group of samples since a browned reference sample for comparison was not available.

TABLE 3

Relation of drained weight, vacuum, headspace and total acid to browning of commercial canned grapefruit sections during storage

"Warehouse" samples				
Drained wt. grams	Vacuum inches	Headspace 1/16"	Total acid-%	Color score
November pack				
162	1.1	4.1	0.97	2.8
152	4.0	4.4	0.96	2.6
138	7.3	5.4	0.86	2.3
March pack				
158	1.5	4.6	1.17	3.1
149	8.1	5.6	1.15	2.9
140	12.8	6.1	1.13	2.8

dent from the maximum and minimum values for the various characteristics (Table 1). For example, in the "packing date" samples total acid ranged from 0.72 to 1.36%, headspace from 3/16 to 8/16 inch and ascorbic acid from 19.7 to 30.3 mg./100 ml.

Relation of total acid and pH to color. All results reported in Tables 2, 3, and 4 show good correlation between total acid and color. Samples having good color usually had a low total acid. Although the differences in pH were small, the data indicate a trend for the darker samples to be slightly lower in pH.

When the "warehouse" samples were examined and compared, the pack processed in November was found to have an average acidity of 0.93% and was lighter in color than the March samples that had an average acid value of 1.15%; however, the March samples were more uniform in color. There were great differences in the color of the November samples; some of these samples were of good color and others were poor. The results (Table 2) for the two "warehouse" packs show, that if there is a difference in browning characteristics of canned grapefruit sections prepared early and late during the processing season, then the difference is also related to the acid content of the packed product.

From the data obtained by the examination of the "packing date" samples, it became evident that the packs were very uniform in quality throughout the entire season. Results from an examination of a small 5 can sample from each packing date gave random results, without a definite pattern as to acid-browning; however, when the data from all of the 35 cans from the 7 packing dates were listed and examined, then the acid, pH, color relationship was apparent (Table 2). The panel was able to arrange these samples into 5 color groups, and the dark-colored samples, regardless of packing date, were found to have a high average acid content and low pH.

The data reported in Table 4, from the examination of the experimental "acid level" packs, confirmed the acid-browning relationship. Samples in cans of sections to which 4 ml. of citric acid solution had been added were the darkest in color, and those with 2 ml. of added acid were darker than the control pack to which no acid was added. The samples with 2 ml. of added sodium hydroxide solution were practically equal in color to the grapefruit sections in the control pack, which contained no added alkali.

Other factors not yet identified might influence the degree of browning. Dark-colored sections were found more frequently when the acidity was high; however, occasionally, a browned sample was found having a low acid content, or a sample with relatively high acid was light in color. Therefore, changes in color during storage in grapefruit segments in a pack can not be predicted from acid titration of a few samples, but this may be done provided a fairly large number of cans are checked.

Relation of Brix value and ascorbic acid to color. The Brix value does not appear to be a major factor concerning the darkening of canned grapefruit sections during storage. Data in Table 2 show a trend for the color to be slightly darker as the Brix value increased; however, in the November pack there was almost no difference in the color of the grapefruit sections, even though the Brix values ranged from 17.8 to 19.7. It should also be mentioned that when individual data from each can was being tabulated, it was noted that at a given Brix-acid ratio, the samples with the lower acid and Brix were generally of the best color.

The ascorbic acid was found to vary in a random manner when compared with other characteristics of the canned grapefruit sections and no relationship was apparent between it and the color of the samples.

Relation of drained weight, vacuum and headspace to color. Drained weight, vacuum and headspace in cans of grapefruit segments were found to be related rather closely. When the drained weight was high, as shown in Table 3, the vacuum and headspace were low. A higher drained weight of sections indicated a higher percentage fill resulting in less headspace, since the volume of syrup used was constant.

Drained weight, and therefore vacuum and headspace, may sometimes indirectly affect the color of grapefruit sections. This possibility is indicated by

TABLE 4

Effect of acidity on the color and other characteristics of canned grapefruit sections (Average values for five can sample from each experimental pack after storage at 90° F. for 6 months)

	Total acid-%	Color rank	pH	Brix value	Ascorbic acid mg./100 ml.	Drained wt. grams	Vacuum inches	Headspace 1/16"
Control	1.15	1.7	3.20	16.9	24.5	142	8.8	5.0
Citric acid (5.8 N)								
4 ml. added	2.06	4.0	2.95	18.9	28.3	133	15.0	7.4
2 ml. added	1.53	2.9	3.19	17.5	25.4	142	11.6	5.8
Sodium hydroxide (5.8 N)								
2 ml. added	1.00	1.9	3.79	17.1	23.7	153	13.4	7.0

the data in Table 3, concerning the "warehouse" samples in which the total acid was relatively constant. When more sections were packed per can, as indicated by higher drained weights, the drained syrup had the highest total acid content, which in turn varied with browning, although the differences were not large. The dilution of the in-can syrup depends upon the weight of sections packed per can, thus the cans with high drained weights tended also to have lower Brix values. Approximately 25% of the November and 19% of the March "warehouse" samples were over-filled and showed positive pressure when checked for vacuum.

The high-drained weight, high-acid, poor-color relationship, noted in the "warehouse" samples (Table 3) was apparent only when fairly uniform fruit was packed and when a large number of cans were checked. This relationship may be easily obscured, as is shown by results from the experimental "acid level" packs (Table 4). Different women filled the cans of sections used in these packs, and the pack with the highest acid level happened to be filled by a sectionizer in such a manner that an average drained weight of 133 g. resulted, while the cans for the low-acid level pack were filled by another woman so that an average drained weight of 153 g. occurred. This difference in the quantity of sections put into the cans was great enough to conceal the pattern of low-drained weight with low acid, shown in the "warehouse" samples, especially since the largest quantity of acid was added to the cans containing the smallest amounts of sections.

No relationship between color and headspace was evident from the other data, presented in Table 2; however, a very slight trend was noted between color and vacuum.

SUMMARY

A study was made to determine the relationship between the browning of canned grapefruit sections during storage and some of their other physical and chemical characteristics. A total of 151 cans from 10 packs obtained from 2 commercial plants were checked for color, total acid, pH, ascorbic acid, and Brix value, as well as drained weight, vacuum and headspace. Seven of the packs were collected every 2 weeks during a packing season, two packs had been stored in a commercial warehouse and contained browned sections and in 3 experimental packs the acid levels were adjusted by the addition of either citric acid or sodium hydroxide solutions. Products were examined either after storage for 6 months at 90° F. or after storage in a warehouse for 10 or more months.

Total acid content was the only factor that correlated in most instances with the darkening during storage of canned grapefruit. Browning occurred more frequently in products with a high acid content and a low pH. Ascorbic acid could not be correlated with color to any significant degree and variations in Brix values appeared to be only a minor factor. Where overpacking of cans occurred, as in two of the packs, high drained weight, low vacuum, small headspace, high acid and poor color resulted. Considerable can-to-can variation was found in the characteristics of the products examined.

ACKNOWLEDGMENTS

Thanks are extended to Snively Groves, Inc., California Packing Corporation and Pasco Packing Company who supplied the canned grapefruit packs used in this investigation. The help of R. W. Barron and Julia Boyette in making some of the analytical determinations was appreciated.

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Application of Specific-Gravity Techniques for the Evaluation of Quality of Sweet Corn[a, b]

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As the maturity of sweet corn progresses, the kernels go through maturation processes generally referred to as milk, cream, and dough stages of maturity. The maturity of the raw corn has been shown to be directly related to the quality of the finished product *(7)*. Therefore, if the maturity of the sweet corn is determined before processing, the processor should have an indication of the quality of the processed product.

Techniques for the evaluation of sweet corn maturity have been studied by many investigators. Several workers have stated that specific gravity can be used as a measurement of maturity in sweet corn *(3, 5, 13, 14)*. As early as 1922, Burton *(3)* indicated that specific gravity could be used as a method of differentiating between old and young corn. Culpepper and Magoon *(5)* determined the specific gravity of totally removed kernels of sweet, dent, flour, flint and waxy types of corn. They *(5)* observed that the density of the kernel varied with stage of maturity and with type; that there was little difference between density of the immature kernels and that the specific gravity of the sweet corn, except in the immature stages, was less than that of other types. Lee, DeFelice and Jenkins *(14)*, determining specific gravity of frozen corn by weighing the thawed whole kernel corn in air and weighing it in brine and xylene-carbon tetrachloride solutions (adjusted to a specific gravity of 1.0), obtained high coefficients when correlating the specific gravity with organoleptic ratings. As a result of their study, they *(14)* suggested that fancy frozen whole kernel corn would have a specific-gravity value (brine method), falling within the range of 1.080 to 1.118; reject because of immaturity all with a value of 1.079 and lower; and reject because of overmaturity all with a value of 1.119 or higher. Gould *(6)* used a modified National Potato Chip Institute potato hydrometer with an 8-pound sample to measure the specific gravity of raw sweet corn, and established grade limits for canned whole kernel corn.

Several other objective tests used to determine the maturity and quality of sweet corn are: alcohol insoluble solids test; moisture determination; pericarp content; and succulence by means of the succulometer. The alcohol insoluble solids determination has been reported to be a reliable measure of maturity of fresh, frozen and canned sweet corn *(8, 9, 11, 15)*; it is used by the U. S. Department of Agriculture and the Food and Drug Administration as one of the methods of segregating Standard from Substandard canned whole kernel corn *(16, 18)*. Twigg *et al. (15)* recently replaced the moisture feature of the "Trimetric Tests" with the alcohol insoluble solids determination. The moisture content of sweet corn determined after silk emergence has been reported by Huelsen and Michaels *(10)* to be closely related to maturity. Gould *et al. (8)* found the test for pericarp percentages to be a good method for determining the tendencies of yellow sweet corn. Succulence determined by means of the succulometer has been reported by Kramer *(12)* to be equally as accurate as the moisture test on the raw product and the alcohol insoluble solids test on canned corn. However, according to Barton *(1)* there is only fair correlation between the raw and processed product when the succulometer is used to measure maturity. He has stated *(2)* that the succulometer is a "measure of maturity in terms of capacity to hold moisture."

In this study specific-gravity indices of fresh, canned and frozen whole kernel sweet corn were compared to indices obtained by presently accepted tests of maturity; and the specific-gravity values were in turn evaluated in terms of U. S. Tenderness and Maturity scores of canned *(16)* and frozen *(17)* whole kernel corn.

MATERIALS AND METHODS

The sweet corn used in this study grew during the years 1954, 1955 and 1956 on the Horticulture Farm at The Ohio State University, Columbus, Ohio. During the 1954 and 1955 seasons samples of two commercial varieties, Tendermost and Victory Golden, were studied; yellow sweet corn samples from the 1955 and 1956 Variety Trials were used (Table 1). For simplicity, the varieties Tendermost and Victory Golden of the 1954 and 1955 seasons will be referred to as Tendermost and/or Victory Golden samples; and the varieties used in the Variety Trials will be designated as a group and will be referred to as Variety Trial samples.

Samples were taken, in most cases, from 4 harvests of 4 plantings of each variety (Tendermost and Victory Golden) planted on 4 dates (approximately 100 growth degree days apart—base temperature 50° F.) for the 1954 and 1955 seasons. There were one to 3 harvests of the varieties used in the Variety

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[b] Journal Article No. 43-57 of the Ohio Agricultural Experiment Station, Wooster, Ohio. This work in part was initiated in 1953 as part of a cooperative project between the Ohio Agricultural Experiment Station and the U. S. Department of Agriculture under the Agricultural Marketing Act of 1946.

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TABLE 1

The variety, seedsman lot numbers, and seed source of the varieties used in the 1955 and 1956 variety trials [1]

Variety	Seedsman Lot No.	Seed Source
1955		
Tenderfreezer	34341	Michael-Leonard
Tenderchief	34139	Michael-Leonard
Ioana (W.S.)	38131	Michael-Leonard
Golden Yield	20653	Michael-Leonard
Longchief	22410	Michael-Leonard
N. K. 199	3052/B2	Northrup-King
Golden Monarch	3052/B1	Northrup-King
K. V. F. 54-105	2024	Corneli
Golden Hybrid 2057	43936	Woodruff
Golden Hybrid 3021	43984	Woodruff
Golden Standard	.....	Abbot and Cobb
Asgrow Golden 50	3447-240	Asgrow
X. P. 103	W52703	Asgrow
Foremost Y1	18106	Ferry-Morse
Iochief	43948	Woodruff
1956		
Tendermost	34748	Michael-Leonard
Gold Standard	C40	Abbott and Cobb
Tenderchief	34139	Michael-Leonard
Golden Yield	20653	Michael-Leonard
Longchief	20304	Michael-Leonard
N. K. 199	3052/7	Northcup-King
K. V. F. 54-105	2024	Corneli
Golden Hybrid 3021	43984F	Woodruff
F-M Cross (Foremost Y-1)	18106	Ferry-Morse
Victory Golden	45978	Woodruff
Streamliner (K. V. F. 50-15)	2403	Corneli
Asgrow Golend 60	33508-130	Associated
Yieldcross	2054	Michael-Leonard
Golden Hybrid 4309	869-4 No. 4	Woodruff
Code 10	.....	Green Giant
Code 18	.....	Green Giant
Code 22	.....	Green Giant

[1] Hereinafter referred to as Variety Trials.

Trials and samples were taken according to harvests. In general, the first harvest of all plantings was made during the milk stage. Maturity of the corn in the field was determined by the thumb-nail test, growth degree days, and number of days from silking. Corn was harvested in the morning and brought directly to the pilot plant laboratory. It was prepared for processing and processed according to acceptable commercial practices for canning and freezing. Samples were drawn for objective analyses after the cutting operation, before fill (after blanching) into the containers, and after storage of the canned and frozen samples of whole kernel corn.

Three specific-gravity techniques *(4)* were employed on the fresh product in addition to the AIS determination *(18)*, and moisture evaluation (vacuum oven method *(4)*). The specific gravity was determined; (a) by taking an adequately drained sample of whole kernel corn (drained for 2 minutes on a 8-mesh 12 inch screen) and weighing in air, 6 pounds (weighed to a ¼ oz.) into a 5-mesh wire basket 12 inches in diameter and 4½ inches high, or (b) weighing as rapidly as possible approximately 100 g. (weighed to 0.01 g.) into a basket of 14 by 17 mesh wire about 2¼ inches in diameter and 3¼ inches high. Then the corn samples were rapidly weighed in water of known specific gravity. The specific gravity was calculated as follows: weight of the corn in air multiplied by the specific gravity of the water, divided by the difference between the weight of corn in air and the weight of the corn in water. The third method (c) consisted of a modified National Potato Chip Institute potato hydrometer which used an adequately drained 6 pound sample placed in the basket accompanying this unit which had been lined with cheese cloth. With the cheese cloth enclosed about the corn, the hydrometer and basket were placed into a 50-gallon galvanized can filled with water. The hydrometer value was read directly from the scale on the hydrometer. This scale indicated the specific gravity of an 8-pound sample of potatoes; but, since only a 6-pound sample of corn was used, the scale would no longer read directly in specific-gravity units. Therefore, the scale was interpreted as hydrometer values and will be referred to as such. Because of sample size, the potato hydrometer and 6-pound specific-gravity techniques were limited to fresh cut or blanched corn samples. It required approximately 15 minutes to secure a specific-gravity reading by each of the three methods. The 100 g. specific-gravity technique along with alcohol insoluble solids and percent pericarp (Tendermost and Victory Golden samples only) objective tests were applied to the processed products. The Tendermost and Victory Golden canned and frozen samples were graded by a U. S. Department of Agriculture Processed Products Inspector according to the present U. S. Standards for Grades of Canned and Frozen Whole Kernel Corn *(16, 17)* and for this study the grades were evaluated in terms of Tenderness and Maturity scores.

In order to further evaluate the specific-gravity techniques, the Tendermost and Victory Golden samples from the 1955 season taken from the same sample points as previously mentioned were chemically analyed. From these chemical determinations the following substances were determined from alcohol preserved samples and calculated on a fresh weight basis; total solids, moisture, alcohol soluble solids, reducing sugars nonreducing sugars, total sugars, and amino acid nitrogen from the alcohol extract, alcohol insoluble residue, and the total reserve polysaccharides.

RESULTS AND DISCUSSION

Relationship of specific-gravity techniques applied to fresh whole kernel sweet corn. Values obtained from fresh cut corn with the 100 g. and 6-pound specific-gravity methods and the potato hydrometer method are compared by means of correlation coefficients presented in Table 2. The accuracy of the 3

TABLE 2

Correlation coefficients of values obtained by specific-gravity techniques applied to fresh cut and blanched Tendermost and Victory Golden (1955 season), and Variety Trial (1955 and 1956 seasons) samples of whole kernel yellow sweet corn[1]

Correlation between	r
Fresh cut corn	
Specific gravity (100 g.) and specific gravity (6 lbs.)	0.952**
Specific gravity (100 g.) and hydrometer	0.937**
Specific gravity (6 lbs.) and hydrometer	0.918**
Blanched corn [1]	
Specific gravity (100 g.) and specific gravity (6 lbs.)	0.923**
Specific gravity (100 g.) and hydrometer	0.911**
Specific gravity (6 lbs.) and hydrometer	0.835**

[1] No 1956 season's data for blanched samples of Variety Trial sweet corn.

** Significant at the .01 level.

methods appears to be comparable, and highly significant relationships are indicated. The 6-pound and 100-g. specific-gravity methods appear to be the best correlated of the techniques, although the differences are not very large.

When the specific-gravity and potato hydrometer techniques are evaluated in terms of the mean ($\bar{x}$), standard deviation (Sx), standard error of the mean ($S\bar{x}$), and coefficient of variability (V), it appears that the potato hydrometer method embodied the lowest variability or the least amount of error (Figure 1). However, since the hydrometer values were limited from approximately 1.050 to 1.095 (scale graduated on potato hydrometer), the smaller variability is probably a result of the smaller range of values. Considering the 100-g. and 6-pound methods, there appears to

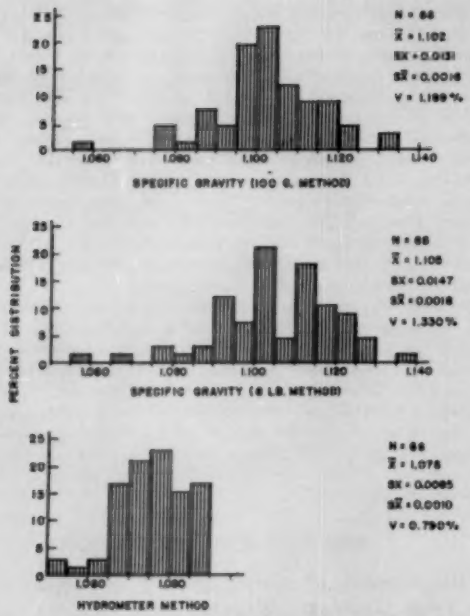


Figure 1. Frequency distribution of specific-gravity (100 g. & 6 lb.) and potato hydrometer values of fresh (cutter sample) tendermost and victory golden (1955 season) and variety trial (1955 & 1956 seasons) whole kernel yellow sweet corn.

be less variability with the 100-g. method and its mean is 0.003 specific-gravity units lower.

When the specific-gravity and potato hydrometer values of the blanched whole kernel corn samples were compared, highly significant relationships were observed (Table 2). These correlation coefficients are slightly lower than those of the fresh cut corn samples, but are above the minimum value generally used for prediction purposes ($r = \pm 0.80$).

Relationship of specific-gravity techniques applied to fresh corn to the specific gravity of canned and frozen whole kernel corn. In order for the specific-gravity and potato hydrometer methods to be useful in predicting finished product maturity, the values obtained on the fresh product should correspond or correlate with the values obtained on the processed product. This relationship, tested with the correlation coefficient, Table 3, was found to be highly significant and the "r" values were well within the predictable range. In order to interpret the specific-gravity values obtained from fresh cut corn in terms of processed product specific gravity, regression lines were plotted and these are presented in Figures 2 and 3.

Relationships of values obtained from specific-gravity techniques to percentage of pericarp, moisture content, alcohol insoluble solids, and some of the chemical constituents of whole kernel yellow sweet corn. The specific-gravity and potato hydrometer values of fresh cut Tendermost, Victory Golden, and Variety Trial sweet corn samples appear to be closely related to the degree of maturity as indicated by alcohol insoluble solids and moisture content (Table 4). The specific-gravity values appear to be somewhat

TABLE 3

Correlation coefficients for values obtained from specific-gravity techniques applied to fresh cut corn and specific gravity of Tendermost and Victory Golden (1955 season) and Variety Trial (1955 and 1956 seasons) canned and frozen whole kernel yellow sweet corn [1]

Correlations between		r
Fresh	Canned	
Specific gravity (100 g.)	and specific gravity (100 g.)	0.910**
Specific gravity (6 lbs.)	and specific gravity (100 g.)	0.902**
Hydrometer	and specific gravity (100 g.)	0.874**
Fresh	Frozen	r
Specific gravity (100 g.)	and specific gravity (100 g.)	0.930**
Specific gravity (6 lbs.)	and specific gravity (100 g.)	0.929**
Hydrometer	and specific gravity (100 g.)	0.951**

[1] No 1956 season's data for frozen samples of Variety Trial sweet corn.

** Significant at the .01 level.

better related to the moisture content except in the case of the hydrometer values, than to the alcohol insoluble solids.

Processed product specific-gravity values from the three seasons were also related to processed product alcohol insoluble solids content to the extent that the quick specific-gravity method could replace the time consuming alcohol insoluble solids determination; correlation coefficients for the canned and frozen products were 0.928 and 0.943 (significant at 1%) respectively. This is especially applicable to nomographs prepared by Twigg *et al. (15)* for determining U. S. Grades in terms of the Tenderness and Maturity factors of canned and frozen whole kernel sweet corn. Therefore, the specific-gravity determination was incorporated with these nomographs and is presented in Figures 4 and 5.

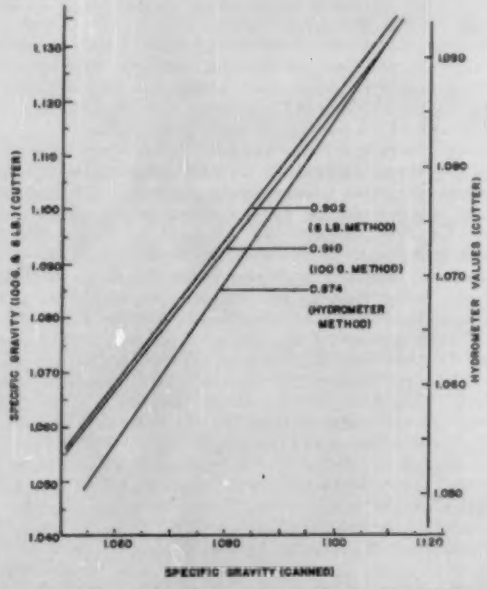


Figure 2. Regression lines of specific-gravity (100 g. & 6 lb. methods) and potato hydrometer values of fresh (cutter sample) and specific gravity (100 g. values) of tendermost and victory golden (1955 season) and variety trial (1955 & 1956 seasons) canned whole kernel yellow sweet corn.

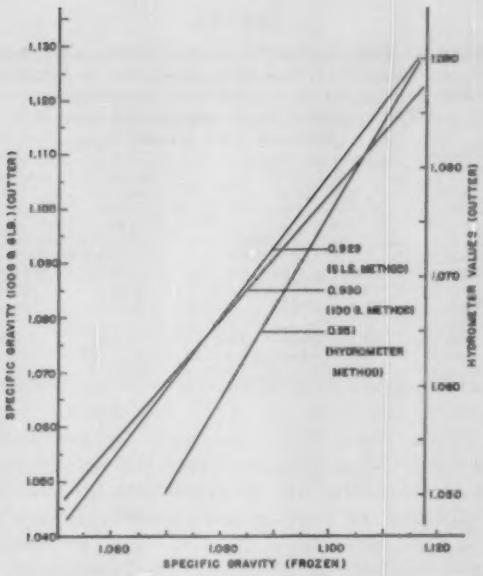


Figure 3. Regression lines of specific-gravity (100 g. & 6 lb. methods) and potato hydrometer values of fresh (cutter sample) and specific-gravity (100 g. values) of frozen tendermost, victory golden and variety trial whole kernel yellow sweet corn. (1955 season)

Specific gravity of the canned and frozen Tendermost and Victory Golden sweet corn (1954 and 1955 seasons) was correlated with the U. S. Tenderness and Maturity scores, -0.824 and -0.720 (significant at 1%) respectively. In order to see if this relationship could be improved, pericarp values were included and the multiple correlation (R) was used. The multiple correlation coefficient obtained (canned, -0.891 and frozen, -0.761 significant at 1%) showed improvement of the relationship. This indicates that specific gravity might be inferred as a fair indicator of tenderness. However, with the sweet corn varieties used today for processing, toughness of pericarp is generally not a problem if the varieties are harvested at the proper stage of maturity. This is believed to be due primarily to the recognition of the importance of pericarp tenderness by corn breeders, seedsmen, and the processing industry.

When the chemically analyzed samples of Tendermost and Victory Golden were ranked in order of increasing total solids, differences significant at the 1% level were observed for all substances analyzed between sample means and the means of sample points. The values obtained with specific-gravity techniques were found to correlate above the generally considered prediction limit ($\pm$ 0.80) with moisture content, total solids, alcohol insoluble residue, and total reserve polysaccharides except between the hydrometer values and total solids (Table 5).

Relationship of specific-gravity values and U. S. Grades based on Tenderness and Maturity scores of canned and frozen whole kernel corn. The frequency distribution was used to classify the specific-gravity values of canned and frozen Tendermost and Victory Golden whole kernel corn from the 1954 and 1955 seasons according to U. S. Grades' A, B, and C Tenderness and Maturity scores assigned by a U. S. D. A. Processed Products Inspector (Table 6).

In order to establish specific-gravity and hydrometer limits for U. S. Grades A, B, and C according to the Tenderness and Maturity scores of canned and frozen whole kernel corn, the data presented in Table 6 are utilized. The dividing lines between U. S. Grade A and B of canned and frozen whole kernel corn are calculated as follows:

(The mean of U. S. Grade A + the standard deviation of U. S. Grade A)—(the mean of U. S. Grade B—the standard deviation of U. S. Grade B) is divided by two. The result of this calculation is subtracted from (the mean of U. S. Grade A + the standard deviation of Grade A).

Hence:

1. Canned whole kernel sweet corn

TABLE 4

Correlation coefficients for values obtained by specific-gravity techniques and moisture content and alcohol insoluble solids (AIS) of fresh cut Tendermost and Victory Golden (1955 season), and Variety Trial (1955 and 1956 seasons) whole kernel sweet corn

Correlations between	r
Specific gravity (100 g.) and % AIS	0.827**
Specific gravity (100 g.) and % moisture	—0.933**
Specific gravity (6 lbs.) and % AIS	0.854**
Specific gravity (6 lbs.) and % moisture	—0.939**
Hydrometer and % AIS	0.896**
Hydrometer and % moisture	—0.874**
% moisture and % AIS	—0.812**

** Significant at the .01 level.

MODIFIED NOMOGRAPH FOR DETERMINING U.S. GRADE FOR TENDERNESS AND MATURITY OF CANNED SWEET CORN FROM DETERMINATION OF SPECIFIC GRAVITY OR A.I.S., PERICARP AND KERNEL SIZE.*

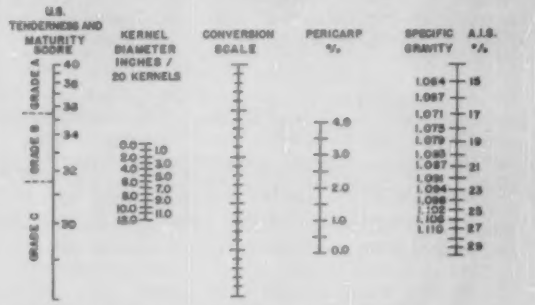
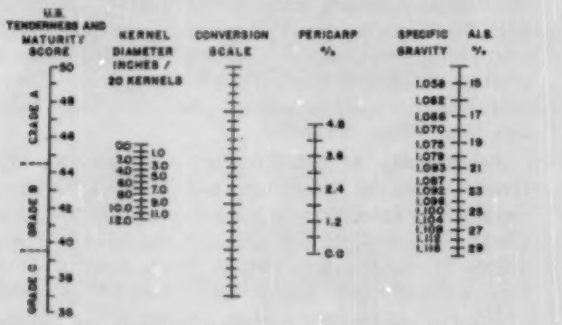

U.S. TENDERNESS AND MATURITY SCORE
GRADE A
GRADE B
GRADE C
KERNEL DIAMETER INCHES / 20 KERNELS
CONVERSION SCALE
PERICARP %
SPECIFIC GRAVITY
A.I.S. %
FROM SELECTED POINTS ON SPECIFIC GRAVITY OR A.I.S. AND PERICARP SCALES, EXTEND LINE UNTIL IT INTERSECTS CONVERSION SCALE. FROM THIS INTERSECTION POINT EXTEND LINE THROUGH SELECTED POINT ON KERNEL DIAMETER SCALE TO TENDERNESS AND MATURITY SCORE SCALE. THIS POINT IS THE NUMERICAL TENDERNESS AND MATURITY SCORE.
* BASIC NOMOGRAPH TAKEN FROM TWIGG ET AL. (15)

Figure 4. Modified nomograph for determining U. S. grade for tenderness and maturity of canned sweet corn from determination of specific gravity or A.I.S., pericarp and kernel size.*

MODIFIED NOMOGRAPH FOR DETERMINING U.S. GRADE FOR TENDERNESS AND MATURITY OF FROZEN SWEET CORN FROM DETERMINATION OF SPECIFIC GRAVITY OR A.I.S., PERICARP AND KERNEL SIZE. *



FROM SELECTED POINTS ON SPECIFIC-GRAVITY OR A.I.S. AND PERICARP SCALES, EXTEND LINE UNTIL IT INTERSECTS CONVERSION SCALE. FROM THIS INTERSECTION POINT EXTEND LINE THROUGH SELECTED POINT ON KERNEL DIAMETER SCALE TO TENDERNESS AND MATURITY SCORE SCALE. THIS POINT IS THE NUMERICAL TENDERNESS AND MATURITY SCORE.

* BASIC NOMOGRAPH TAKEN FROM TWISS ET AL. (15)

Figure 5. Modified nomograph for determining U. S. grade for tenderness and maturity of frozen corn from determination of specific gravity or A.I.S., pericarp and kernel size.*

$$\frac{(1.0768 + 0.0078) - (1.0875 - 0.0075)}{2} = 0.0023$$

$(1.0768 + 0.0078) - 0.0023 = 1.082$ (dividing line between U. S. Grades A and B according to the Tenderness and Maturity scores for canned whole kernel corn).

2. Frozen whole kernel sweet corn

$$\frac{(1.0904 + 0.0112) - (1.1038 - 0.0056)}{2} = 0.0017$$

$(1.0904 + 0.0112) - 0.0017 = 1.100$ (dividing line between U. S. Grades A and B according to the Tenderness and Maturity scores of frozen whole kernel sweet corn).

The number of samples falling into the canned and frozen U. S. Grade B and C categories were limited. However, when the dividing lines were calculated according to the above procedure, the values presented in Tables 7 and 8 were obtained. By means of the calculated dividing lines, Figures 2 and 3 can be utilized to predict the dividing lines for the values obtained by the specific-gravity techniques applied to fresh cut corn; these data are also presented in Tables 7 and 8.

By using the specific-gravity techniques with the determined limits (Tables 7 and 8), a packer would have an indication of the Grade of the processed product. The techniques could be applied to either the fresh cut corn or canned and frozen whole kernel corn.

TABLE 5

Correlation coefficients between approximate chemical composition and values obtained with the specific-gravity techniques for Tendermost and Victory Golden fresh,[1] canned, and frozen whole kernel sweet corn (1955 season)

r	Specific gravity		Hydrometer values [1]
	100 g.	6 lb.[1]	
Moisture	−0.914**	−0.831**	−0.817**
Total solids	0.832**	0.831**	0.693**
Alcohol soluble solids	0.473**	0.008	−0.061
Reducing sugars (glucose)	0.627**	0.246	0.177
Nonreducing sugars (sucrose)	−0.027	−0.543**	−0.589**
Total sugars (glucose)	0.136	−0.405**	−0.468**
Amino acid nitrogen	0.274**	−0.070	−0.147
Alcohol insoluble residue	0.932**	0.881**	0.874**
Total reserve polysaccharides (glucose	0.922**	0.860**	0.846**

[1] Hydrometer and 6 lb. specific-gravity techniques were used only on the fresh (cutter and blanched) samples.
** Significant at the .01 level.

TABLE 6

Summary of statistical analyses of specific-gravity values classified according to U. S. Grades' A, B, and C Tenderness and Maturity scores of canned and frozen Tendermost and Victory Golden whole kernel yellow sweet corn (1954 and 1955 seasons)

	N	Mean ($\bar{x}$)	Standard deviation (Sx)	Standard error of mean ($S\bar{x}$)	% coefficient of variability (V)
Canned					
Grade A	42	1.0768	0.0078	0.0012	0.724
Grade B	16	1.0875	0.0075	0.0019	0.690
Grade C	17	1.0919	0.0039	0.0019	0.357
Frozen					
Grade A	49	1.0904	0.0112	0.0016	1.027
Grade B	16	1.1038	0.0056	0.0014	0.507
Grade C	10	1.1045	0.0079	0.0025	0.715

TABLE 7

Relationship of values obtained by specific-gravity techniques of fresh cut corn and specific gravity of canned corn according to U. S. Grades' A, B, and C Tenderness and Maturity scores

	Limits for minimum grades		
	A	B	C
Fresh cut corn			
Specific gravity			
(100 g. method)	1.094	1.107	1.114
(6 lb. method)	1.096	1.109	1.116
Hydrometer	1.071	1.077	1.081
Canned corn			
Specific gravity	1.082	1.092	1.096

CONCLUSIONS

As a means of quickly determining the degree of maturity of sweet corn, specific-gravity techniques have been evaluated.

Of the specific-gravity techniques studied, it is recommended that the 6-pound method be applied to the fresh cut corn because of its simplicity of operation, inexpensive equipment and large sample size; and the 100-g. method is recommended for use with canned and frozen whole kernel corn.

Good relationships were shown to exist with the specific-gravity techniques when they were applied to fresh cut and blanched whole kernel corn. This was also true of the relationship between the specific gravity of the fresh cut corn and the processed product.

Values obtained with the specific-gravity techniques applied to the fresh cut and processed whole kernel

TABLE 8

Relationship of values obtained by specific-gravity techniques of fresh cut corn and specific gravity of frozen corn according to U. S. Grades' A, B, and C Tenderness and Maturity scores

	Limits for minimum grades		
	A	B	C
Fresh cut corn			
Specific gravity			
(100 g. method)	1.102	1.106	1.116
(6 lb. method)	1.106	1.111	1.122
Hydrometer	1.076	1.078	1.086
Frozen corn			
Specific gravity	1.100	1.103	1.112

corn showed good relationships with fresh product moisture content and fresh and processed product alcohol insoluble solids.

Processed product specific-gravity values were incorporated into nomographs used to determine U. S. Tenderness and Maturity scores of canned and frozen corn objectively.

As the result of chemical tests, it was found that total solids, moisture content, alcohol insoluble residue, and total reserve polysaccharides, could be predicted by the use of specific-gravity techniques.

Minimum Grade limits were established for values obtained from specific-gravity techniques on fresh cut, canned, and frozen whole kernel corn.

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Radiation Sterilization of Apple Slices[a, b]

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MANY OF THE EFFECTS of radiation on foods and food constituents are known *(2, 3, 4)*. However, in few instances have these studies been conducted where control of the food was possible from harvest to acceptance testing. Since radiation is relatively new, the effect of almost every variable to which the food is exposed must be considered with respect to its interaction with radiation. The present study explored the effect of some raw product and processing variables involved in producing canned irradiation-preserved apple slices.

Specific objectives of the experiments reported here were: (a) to determine the effects of maturity, ripeness, and preparation treatment on the acceptability of apple slices subjected to various radiation doses and evaluated as slices after various periods of storage, (b) to determine the effects of the same variables when the product was evaluated as slices which were incorporated into pies along with the usual spices and (c) to determine the effect of radiation on prepared apple pie fillings.

MATERIALS AND METHODS

Apples. The Jonathan variety was used. All apples were picked from the same trees, at the same time, and divided into two groups, mature and immature, on the basis of skin color. Each group was subdivided into two lots, one of which was processed immediately and labeled unripened and the other was stored at 75° F. for 12 to 15 days for ripening (Figure 1). Each lot of apples was washed, machine pared, cored and sliced into 12 segments.

The pH of the juice, soluble solids content, and titratable acidity of the various lots were determined (Table 1). Titratable acidity was determined by titration of the filtrates of pulped apples with standard sodium hydroxide and is expressed as per cent of malic acid. These experimental values are in accord with other reported data *(6)* and show there were physiological differences among the 4 lots.

Apple slices. Each of the 4 lots were subdivided into 9 portions for preparatory treatment as indicated in Figure 1.

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[b] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 751 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

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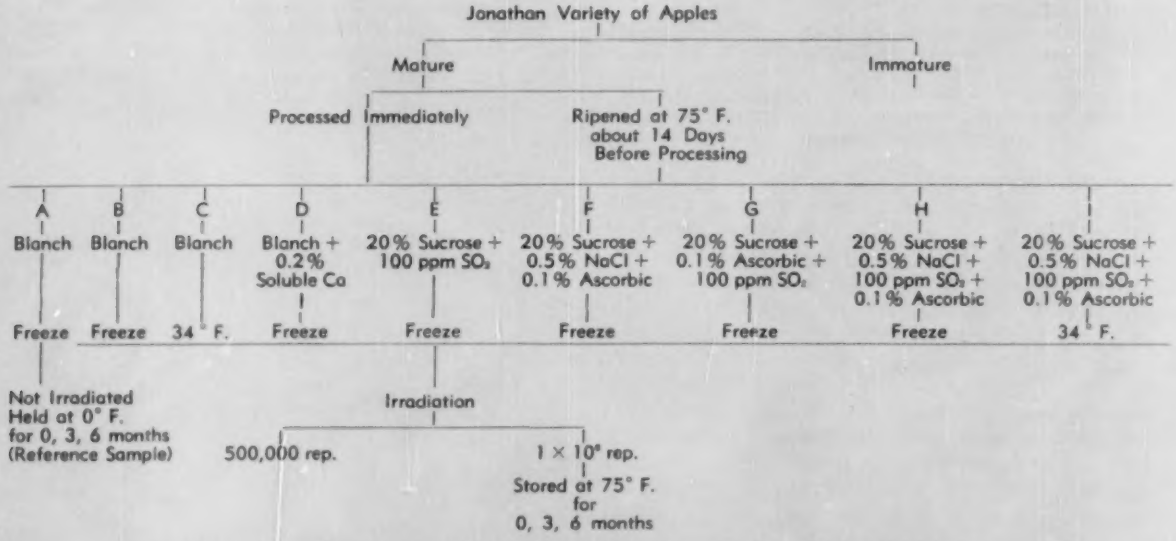
Jonathan Variety of Apples
Mature
Immature
Processed Immediately
Ripened at 75° F. about 14 Days Before Processing
A Blanch
B Blanch
C Blanch
D Blanch + 0.2% Soluble Ca
E 20% Sucrose + 100 ppm SO2
F 20% Sucrose + 0.5% NaCl + 0.1% Ascorbic
G 20% Sucrose + 0.1% Ascorbic + 100 ppm SO2
H 20% Sucrose + 0.5% NaCl + 100 ppm SO2 + 0.1% Ascorbic
I 20% Sucrose + 0.5% NaCl + 100 ppm SO2 + 0.1% Ascorbic
Freeze
Freeze
34° F.
Freeze
Freeze
Freeze
Freeze
Freeze
34° F.
Not Irradiated Held at 0° F. for 0, 3, 6 months (Reference Sample)
Irradiation
500,000 rep.
1 × 10⁶ rep.
Stored at 75° F. for 0, 3, 6 months
Number of Samples: 2 (maturities) × 2 (ripeness) × 9 (treatments) × 2 (irradiation doses) × 3 (storage periods) × 3 (replications) = 648 (576 irradiated and 72 reference)

Figure 1. Outline for Radiation Sterilization of Apple Slices.

TABLE 1

Physiological Characteristics of Jonathan Apples After Various Storage Periods

Apples	Storage time days	Storage temperature °F.	pH of juice	Soluble solids %	Titratable acidity as malic acid %
Mature					
Lot 1, unripened..	14	34	3.41	13.9	.57
Lot 2, ripened.....	14	75	3.41	14.1	.54
Immature					
Lot 3, unripened...	14	34	3.40	12.5	.56
Lot 4, ripened.....	14	75	3.55	12.1	.50
Mature[1].....	146	34	3.88	13.6	.46

[1] These apples used for pie (Objective 2) and pie filling (Objective 3) experiments only.

Samples designated as blanch were placed in a boiling 12% sucrose solution adjusted to pH 4.0 with citric acid for 3 to 3½ minutes. Remaining treatments involved a deaeration by immersing the slices in various chemical solutions (Figure 1), placing in a retort and drawing a vacuum of 27–28 in Hg. for 15 minutes. After the blanching or deaeration treatments the slices were drained for 2 minutes, packed full into No. 2 fruit enamel cans and vacuum sealed. The canned samples were either frozen or held at 34° F. until after irradiation. Half the samples from each treatment received a radiation dose of 0.5 megarep and the others one megarep. All samples with the exception of the frozen nonirradiated reference samples were stored at 75° F. for 0, 3, and 6 months. Three replications were made of the above procedure and all samples were organoleptically evaluated as slices.

Apple slices evaluated in pies. A duplicate series of apple slices were prepared as shown in Figure 1 except that maturity and ripeness variations were omitted. Only mature apples which had been stored at 34° F. were used. Prepared, irradiated samples were stored at 75° F. for 3 months. Prior to evaluation, the samples were mixed with ½ teaspoon of cinnamon, ¼ teaspoon of nutmeg, ½ cup sugar, 1 tablespoon flour, and 1 tablespoon of margerine for each cup of apples and baked into pies.

Prepared pie fillings. Slices were made from mature apples that had been stored at 34° F. The slices were blanched or chemically treated, B and F, respectively in Figure 1. Then pie fillings were prepared from the slices. For every one pound of drained apple slices the following amounts of dry ingredients were used: 80 g. sugar, 20 g. citrus pectin (slow set No. 460, 150 grade, California Fruit Growers Exchange, Ontario, California), 0.3 g. cinnamon and 0.03 g. sodium chloride. The dry ingredients were blended together and mixed with the correct amount of apple slices, packed into No. 2 cans, vacuum sealed, frozen, and irradiated. Before evaluating organoleptically, fillings were placed in uncooked pastry shells without further ingredients and baked.

Radiation source. Samples were irradiated under the direction of Miss Gladys Swope in the high-level gamma irradiation facility at Argonne National Laboratory, Lemont, Illinois. This facility used spent fuel rods.

Taste testing. Lack of suitable objective tests made it necessary to use organoleptic methods for evaluating the samples. Irradiated apple slices were presented to the taste panel in a random manner and the taster scored 8 samples in each group: No more than 4 groups were evaluated in one day. A graded reference sample for purposes of comparison was also present. The taste panel was composed of the same 9 members throughout the study. Each sample was graded in regard to flavor, color and texture. Odor was also included in the evaluation of apple slices *per se*. Scores were based on a 9-point hedonic scale *(5)*. Nine was considered as excellent with 5 as just acceptable.

In Table 2, the design of the taste testing procedure, it can be seen that samples prepared by treatments B and C were always in the same group of 8 samples being evaluated. The same was true for D and E, etc. Thus, there were 4 treatment pairs: BC, DE, FG, and HI. Consequeuently, two kinds of comparison were involved since the comparison within these pairs of treatments is of a higher precision than the comparison between pairs of treatments. This pairing of treatments was taken into account in the statistical analysis and is reflected in the various tables of treatment means by the presentation of two estimates of error, one appropriate to within-pairs and one to between-pairs comparisons.

Statistical analysis. The statistical procedure was analysis of variance, in which pairs of treatments occurred in balanced incomplete blocks of 2 pairs each and for which interblock information was not recovered. Maturity, ripeness, irradiation dose, storage and preparatory treatment were examined for main effects and interactions. The 1% significance level was used. Thus, only the main and interacting effects which were found to be significant at the 99% confidence level are reported separately and designated as being significant.

TABLE 2

Design of Organoleptic Testing Procedure for Irradiated Apple Slices

Replication	Order in which evaluated	
	Set I	Set II
1.....	BCDE[1]	FGHI
2.....	BCFG	DEHI
3.....	BCHI	DEFG

[1] BCDE represents 8 samples since slices prepared by treatments B, C, D, and E at the two levels of irradiation used (see Figure 1) were always evaluated in the same set.

RESULTS

Objective 1: Evaluation as Apple Slices.

Interactions

Radiation Dose and Preparatory Treatment. Mean color scores (Table 3) indicate a significant interaction between irradiation dose and treatment. Samples prepared by blanching (treatments B, C, and D) were less affected by increasing the irradiation dose from 0.5 to 1.0 megarep and were superior to the color of chemically treated samples at 1.0 megarep although less acceptable at the 0.5 megarep level. In the case of each treatment a decrease in the color acceptability of the product was noted with an increase in irradiation dose.

Table 3 shows a typical example of the mean scores for a significant interaction involving a single organoleptic factor. Such tables were prepared for all the significant interactions found in this study, but are not all included here for lack of space. Only the more important tables are given, but others will be discussed.

Maturity and Preparatory Treatment. Samples prepared with mature apples were generally superior in flavor to similar samples prepared with immature apples. However, the texture

TABLE 3

Effect of Preparatory Treatment and Irradiation Dose on the Color of Irradiated Apple Slices Averaged Over Maturity and Ripeness

Preparatory treatment[1]	Irradiation dose in rep		Difference
	500,000	1×10^6	
	Mean color scores		
B.....	6.59	5.88	0.71
C.....	5.27	4.41	0.86
D.....	6.56	5.96	0.60
E.....	6.20	5.19	1.01
F.....	6.75	5.52	1.23
G.....	6.84	5.77	1.07
H.....	6.95	5.72	1.23
I.....	7.09	5.77	1.32

1% significant difference
Between pairs 0.34
Within pairs 0.37

[1] See Figure 1

of the samples varied with both maturity and treatment so no generalization can be made. Blanching in a sugar and calcium solution (treatment D) resulted in superior flavor and texture for each maturity of the apples used.

Ripeness and Preparatory Treatment. The temperature before and during radiation appears to be involved in this interaction since the flavor of the frozen samples was much better than that of samples irradiated at 34° F. with all other variables being equal. The most desirable treatment based on the statistical analysis was blanching the slices in a sugar and calcium solution (treatment D) regardless of the ripeness of the raw product.

Tables 4 and 5 show the mean scores for color and texture for the interaction between ripeness and treatment. The difference columns in these tables show two interesting trends. First, an increase in color acceptability and a decrease in the texture acceptability were obtained for each preparatory treatment by the use of raw materials that had been allowed to ripen rather than processed immediately after harvest. For texture the differences were as high as 3.47 organoleptic units. Secondly, the differences in the case of the blanched samples (treatments B, C, and D) for both color and texture were not nearly so marked as the differences in the other treatments. Consequently, if samples are blanched before irradiation, ripeness does not appear to be as important a consideration.

TABLE 4

Effect of Ripeness and Preparatory Treatment on the Color of Irradiated Apple Slices Averaged Over Maturity

Preparatory treatment[1]	Ripeness		Difference
	Processed immediately	Ripened 14 days at 75° F.	
	Mean color scores		
B	6.14	6.34	−0.20
C	4.68	5.00	−0.32
D	5.95	6.57	−0.62
E	5.20	6.18	−0.98
F	5.51	6.76	−1.25
G	5.79	6.81	−1.02
H	5.66	7.01	−1.35
I	6.18	6.68	−0.50
1% significant difference Between pairs 0.34 Within pairs 0.37			

[1] See Figure 1

TABLE 5

Effect of Ripeness and Preparatory Treatment on the Texture of Irradiated Apple Slices Averaged Over Maturity

Preparatory treatment[1]	Ripeness		Difference
	Processed immediately	Ripened 14 days at 75° F.	
	Mean texture scores		
B	5.60	5.43	0.17
C	5.30	5.18	0.12
D	6.09	5.81	0.28
E	6.83	4.33	2.50
F	7.08	3.61	3.47
G	7.00	3.79	3.21
H	6.74	3.78	2.96
I	7.07	4.75	2.32
1% significant difference Between pairs 0.50 Within pairs 0.43			

[1] See Figure 1

Main Effects

Preparatory Treatment. From the mean scores presented in Table 6 it is evident that blanched samples irradiated in the frozen state (treatments B and D) were superior in both flavor and odor to samples obtained from all other treatments.

TABLE 6

Effect of Preparatory Treatment on the Scores for the Flavor and Odor of Apple Slices Averaged Over Maturity and Ripeness

Preparatory treatment[1]	Mean scores	
	Flavor	Odor
B	5.79	5.89
C	5.10	5.32
D	6.04	5.89
E	5.54	5.28
F	5.66	5.53
G	5.47	5.34
H	5.44	5.39
I	5.56	5.37
1% significant difference Between pairs	0.197	0.120
Within pairs	0.156	0.101

[1] See Figure 1

Storage at 75° F. All 4 organoleptic factors were affected by storage at 75° F. following irradiation as shown in Table 7. Since there was essentially no difference in the scores between the samples stored for 3 and 6 months, the average mean scores for these two storage periods were subtracted from the mean score for the samples evaluated immediately after irradiation. The undesirable chemical reactions induced by irradiation appear to be completed during the first 3 months of storage, which means that the storage life of the product is probably longer than 6 months for those samples acceptable after that period of storage. This was borne out by an examination made after 12 months' storage. Although these results were not included in the statistical analysis, they revealed no further undesirable change in the product.

TABLE 7

Effect of Storage at 75° F. on the Organoleptic Scores of Irradiated Apple Slices Averaged Over Maturity and Ripeness

Storage time	Total samples	Mean scores			
		Flavor	Color	Texture	Odor
0 months	192	6.13	6.66	5.97	5.98
3 months	192	5.37	5.69	5.28	5.29
6 months	192	5.23	5.73	5.32	5.23
Difference between 0 months and the average of 3 and 6 months		0.83*	0.95*	0.67*	0.72*

* Indicates significance at the 1% level

Irradiation Dose. The irradiation dose affected the flavor, color, and texture of the samples and, as expected, those that received 1 megarep were less acceptable.

Maturity. Maturity of the apple slices affected the color and odor acceptability of the irradiated samples. A difference was expected since the physiological condition of the apples is different at each stage of maturation. Both color and odor were superior in the case of samples prepared with mature apples.

Ripeness. Ripeness had no significant main effect except on odor. In this case the odor was scored higher if the raw product was processed immediately.

Objective 2: Evaluation in Pies

Interactions.

Storage and Preparatory Treatment. The color acceptability of slices in pies decreased with storage of the slices up to 3 months. The blanched-frozen samples (treatments B and D) showed less decrease in color acceptability and were superior to all others after 3 months of storage.

Main Effects.

Preparatory Treatments. A correlation exists between flavor and texture in regards to preparatory treatment, as shown in Table 8. It is apparent that pies prepared with blanched apple slices (treatments B, C, and D) were superior in flavor and texture to pies prepared with chemically treated slices.

TABLE 8

Effect of Preparatory Treatment on the Mean Scores for the Flavor and Texture of Apple Slices in Pies Averaged Over Maturity and Ripeness

Preparatory treatment[1]	Mean scores	
	Flavor	Texture
B	6.99	6.73
C	6.73	6.57
D	6.76	6.77
E	6.17	5.74
F	6.07	5.64
G	6.29	5.45
H	6.28	5.77
I	6.10	6.34
1% significant difference		
Between pairs	0.42	0.58
Within pairs	0.34	0.39

[1] See Figure 1

Irradiation Dose. Increasing the irradiation dose from 0.5 to 1.0 megarep did not cause any significant deterioration in the flavor and color of apple slices but the texture acceptability was decreased.

Storage at 75° F. Storage of irradiated apple slices for 3 months at 75° F. adversely affected the flavor, color, and texture of the slices even when tested organoleptically in pies. The adverse effect of storage was greatest on the color of the slices. This may be due to the inability of the chemical treatments to completely inhibit browning.

Objective 3: Prepared Pie Fillings

It is possible that addition of spices may protect the apple slices during irradiation or mask a slight off-flavor development and result in a superior product. Consequently, two series of pie fillings were irradiated and evaluated in pies. Because of the small number of samples used, the results were not analyzed statistically, and only the average organoleptic scores are presented (Table 9).

TABLE 9

Organoleptic Scores for Apple Slices in Pies Prepared with Irradiated Pie Fillings Averaged Over Maturity and Ripeness

Preparatory Treatment[2]	Irradiation Dose in Rep × 10^6	Average organoleptic scores[1] Storage Time in Mos.					
		Flavor		Color		Texture	
		0	3	0	3	0	3
B	None	7.06	7.17	7.11	7.39	7.06	7.44
B	0.5	6.78	6.56	6.83	7.33	6.78	5.95
B	1.0	7.00	6.62	6.84	6.28	6.78	5.56
F	None	7.94	7.94	8.56	8.84	7.34	7.56
F	0.5	7.06	6.50	6.89	6.11	6.28	5.61
F	1.0	7.22	5.89	6.33	5.89	6.16	5.56

[1] Represents the average score of 9 tasters for two replications
[2] See Figure 1

Nonirradiated controls were consistently better than samples prepared with irradiated pie fillings. However, all the pies made with the irradiated fillings were acceptable. Samples prepared with fillings irradiated at each of the two dosage levels were less acceptable at the end of the 3-month storage period than initially while the nonirradiated frozen controls were as acceptable after 3 months of storage as initially. At the time of the initial examination there appeared to be little or no difference in the acceptability of the samples irradiated at 0.5 and 1.0 megarep. However, after 3 months of storage the samples that had received the higher irradiation dose had decreased more in their acceptability. There was no readily apparent difference between samples prepared by product treatments B and F.

DISCUSSION

It is difficult to make rigid comparisons between the results of the experiments described under Objectives 1 and 2. However, the difference in acceptability between the blanched and chemicallly treated apple slices appeared to be responsible for most of the significant differences. Blanched samples in the frozen state during irradiation (treatments B and D) were superior to samples prepared by any of the other treatments, regardless of whether they were evaluated as slices or in pies. In general, when the apple slices were judged in pies the adverse effects of the variables were not as great as when judged as slices.

In several instances samples blanched in sugar solutions containing 0.2% soluble calcium (treatment D) showed the highest over-all acceptability. The calcium was included because it is known to act as a firming agent *(1)* but instead of benefiting texture, as expected, it improved flavor and odor. No explanation can be given for this result.

The headspace in the cans at the time of examination was observed to vary with treatment. The variation in headspace represented a decrease in volume of one-tenth to one-third the original. This decrease was apparently caused by radiation at the levels used in this work and represents a distinct disadvantage to radiation sterilization of apple slices. Additional research should be done to delineate the problem and to attempt to solve it. Cans that had been filled with chemically treated slices showed a greater decrease in product volume than those containing blanched slices. This is further support for blanching as the processing treeatment of choice.

No direct comparison can be made of the results for the irradiated pie fillings with the results for pies made with irradiated slices. Nevertheless, there appeared to be no marked difference in acceptability between slices irradiated alone or in combination with spices in the form of fillings.

SUMMARY

The effect of maturity, ripeness, preparatory treatment, and storage on the acceptability of apple slices subjected to various radiation doses was studied. Results indicate that the best over-all procedure is to use mature apples, process immediatelly after harvest, blanch in dilute sugar solutions, vacuum seal, freeze, and irradiate at 0.5 megarep. Under these conditions the apple slices were still acceptable after 6 months of storage at 75° F. When the irradiated slices were incorporated into pies along with the usual spices, and organoleptic evaluations were made, effects of the irradiation were not as marked as when judged as slices. There was no advantage in irradiating apple slices in combination with spices and pectin in the form of prepared pie fillings.

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Container Problems Associated with the Addition of Phosphate to the Curing Ingredients of Pork Products*

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ADDITION OF PHOSPHATE SALTS to the curing brine or as a direct curing ingredient for various pork products has recently become a very extensive practice in the meat packing industry. The addition of phosphate salts to the curing brine was aimed at gaining a higher, more consistent product yield by increasing moisture retention and preventing the loss of soluble proteins *(4)*, and improving the color and texture of the finished product *(3)*. This relatively minor change in the curing ingredients of pork products such as hams and picnics used for canning has necessitated a major change in the container in which it is packed.

The purpose of this paper is to discuss some of the problems encountered in developing a satisfactory metal container for phosphate-cured meats, and the solutions to these problems from the packaging engineering standpoint. It is not within the scope of this paper to consider the *modus operandi* of the phosphates in improving cured meat quality, as this has been the subject of a number of papers in the last few years *(1, 2)*.

Prior to the use of phosphates in curing meats, canned hams and picnics were packed in plain cans with 1.25 lb. hot dipped tinplate bodies. When phosphates were introduced, it soon became general knowledge that unpredictable and variable corrosion of the container and discoloration of the phosphate cured product could be expected.

Before the introduction of phosphates for ham curing, Continental Can Company had investigated the feasibility of enameling large oblong cans for non-sterile luncheon meat and chopped ham for various reasons: (1) on commercially canned products there had been a few instances of a brown discoloration adjacent to the sideseams of containers having plain, hot-dipped bodies; and (2) tin shortages in time of war and tinplate economies were giving impetus to a trend away from the use of hot-dipped tinplate for food cans. As a result of these investigations, considerable knowledge and experience were accumulated regarding the effects of various container materials on product discoloration. It was found that exposed iron was a definite factor in the discoloration of non-sterile luncheon meat and chopped ham (containing no phosphates in the curing ingredients) but could be eliminated by sidestripping plain body cans. Enameling the bodies and ends accentuated the discoloration where there was exposed iron, but the use of an aluminum disc in electrical contact with both the product and the can diminished the discoloration almost completely. Table 1 presents a typical set of data.

These data show product discoloration was occasionally experienced commercially with the plain body container (Code A), but no product discoloration was found in the plain body container with the sideseam having an enamel stripe (Code B); although enameling the can throughout resulted in an increase in product discoloration (Code C), the use of an aluminum disc clinched in the end of the enameled container diminished the discoloration in the controls (Code D).

Use of the aluminum disc was based on the theory that aluminum, being lower in the electrochemical series and anodic to iron, would corrode preferentially thus eliminating product discoloration. It was found that the activity of the aluminum anode is controlled by the composition of the aluminum metal used, the size of the aluminum anode, and the ability of the meat and meat juices to support electrochemical activity. Present anodes were thus designed to accommodate present meat packaging practice and changes in such practices could necessitate anode changes. For economic reasons, however, the sidestriped plain body container was used commercially for non-phosphate treated, non-sterile products in preference to an enameled can with aluminum disc or anode.

When difficulties with phosphate-treated products packed in plain body containers were observed, the experience noted above with non-phosphate treated products was utilized in developing a satisfactory commercial container. It soon became evident that a completely enameled can with an aluminum anode was necessary; in addition, the sideseam of the container would have to be striped with enamel in order to cut metal exposure in the container to an absolute minimum. In the early tests using commercial meat type oleoresinous "C" enamel, enamel blistering was observed. It was theorized that the electrochemical activity of the aluminum anode caused hydrogen to form on the plate surface and subsequent softening and lifting of the enamel. Various types of enamels were tested with similar results; however, an oleoresinous "C" enamel was eventually found which proved blister resistant. The successful performance of this system was demonstrated in a series of test packs made in cooperation with a number of meat packers. How-

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TABLE 1

Discoloration of non-sterile luncheon meat packed in metal cans with variable container components.

Code	Body[b] Enamel	End[c] Enamel	Side-Stripe	Aluminum Anode	Discoloration of Product at Sideseam			
					40 days	90 days	180 days	300 days
A	none	yes	none	none	none	trace	slight	slight
B	none	yes	yes	none	none	none	none	none
C	yes	yes	none	none	trace	trace	moderate	moderate
D	yes	yes	none	yes	none	none	trace	very sl.

[b] Body—1.25# hot dipped tinplate.
[c] Ends—#50 electrolytic tinplate.

ever, because of our continuing interest in the enamel blistering problem, the study of additional enamel systems was continued.

Specifications for a container with the special "C" enamel and aluminum anode were established and used commercially for approximately nine months with a high degree of success. However, a few isolated instances of enamel blistering and peeling occurred in these commercial packs. The failure was found in hams cut a few days after packing and occurred most often when frozen storage products were canned.

It was known that oleoresinous "C" enamels are attacked by free fatty acids, causing rapid dezincing of the enamel, softening, and subsequent blistering and peeling. In products such as chile con carne—where in the presence of an excess of fat an undesirable layer of free fat is found on the surface of the product—it was found that a free fatty acid content in excess of 2% could cause enamel failure with "C"-type enamels. In the case of canned hams and picnics, of course, a layer of fat is always present on most of the surface adjacent to the can lining.

Most of the above discussion refers to the performance of non-sterile meat products. It was found very early in our studies that the sterile processed ham was an entirely different product and its container requirements were not the same as the requirements for the non-sterile productt. The higher processing and storage temperatures resulted in changes in the corrosion characteristics of the container and the product.

In view of the foregoing, a detailed investigation was undertaken to determine:

1. The effect of different levels of free fatty acid on:
   a. The original meat-type oleoresinous "C" enamel, (Enamel A, Formula No. 1) which had demonstrated poor resistance to blistering in early test packs.
   b. The oleoresinous "C" enamel, (Enamel B, Formula No. 2) which had been used commercially for phosphate cured product.
   c. A pigmented enamel (Enamel C) which had performed successfully in test packs but which had not been used commercially because of its cost.
2. The effect of phosphates on free fatty acid production.
3. The free fatty acid content of hams in the various test packs made by Continental and of commercially canned hams involved in instances of enamel failure.
4. Container requirements for phosphate cured hams given a sterile process.

EXPERIMENTAL PROCEDURE

Effect of different levels of free fatty acid

Twelve-ounce luncheon meat cans were prepared with the 3 enamels to be tested and fitted with aluminum anodes. The cans were filled with pure leaf lard and 10% water (by weight). Oleic acid was added to cans of each enamel variable at 0.5%, 1.0%, 2.0% and 3.0% level. The cans were closd on a vacuum closing machine and then processed. One-half the cans of each variable was processed 60 minutes at 230° C. (sterile process) and stored at 70° F. for one week before examining for enamel failure. The balance was processed for 2 hours at 165° F. (non-sterile process) and then stored at 40° F. for one week before examining for enamel failure.

Effect of phosphates on FFA production. Twenty-five pounds of unrendered pork fat were ground and divided into two parts. A curing pickle of the following formula was prepared: 2.5 lbs. water; 13.8 gms. $NaNO_2$; 1.7 gms. $NaNO_3$; and 270.5 gms. NACl. One-half the above pickle was added to 12½ lbs. of the ground pork fat and mixed under 25 in. vacuum for 20 minutes. To the second half of the pickle was added 13.8 g. (0.5%) sodium tripolyphosphate and the phosphate pickle was then mixed with the second portion of ground pork fat. The product was cured at 40° F. for seven days, packed in cans, and processed (both sterile and nonsterile process).

The product was analyzed for oleic acid at the following points:

3) Unrendered fat as received;
2) "Cured" fat just one week after processing
3) Processed product one week after processing

Container requirements for sterile process canned hams. The various curing ingredients used consisted of: (a) 8 ounces sodium tripolyphosphate (Curafos)/100 pounds of meat; (b) 2 ounces $NaNO_2$/100 lbs.; (c) ¼ oz. $NaNO_2$/100 lbs.; and (d) 3½ lbs. NaCl/100 lbs. of meat. Meat cured with ascorbic acid had ascorbic acid added at the rate of ¾ oz./100 lbs. of meat. These concentrations were used in combination or individually. Following vacuum mixing, meat was cured at 40° F. for 48 hours, remixed under vacuum, packed into 211 x 300 test cans, sealed under 25 inches of machine vacuum, and processed 100 minutes at 240° F.

RESULTS AND DISCUSSION

Effect of increasing oleic aid on enamel performance.

Non-sterile Process. As shown in Table 2, failure of both oleoresinous C-type enamels (Enamels A and B) increased with increasing oleic acid content; there was no evidence of enamel failure with Enamel C.

Although Enamel B showed no enamel peeling at the 1% oleic acid level, the enamel was completely removed at the 2% and 3% levels. Enamel A showed excessive peeling on one of three cans at the 2% oleic acid level and on all three at the 3% level. With

TABLE 2

Effect of increasing oleic acid on enamel performance (Non-sterile process)

% Oleic Acid	% Enamel Peeling			% of Enamel Area Dezinced	
	Enamel A	Enamel B	Enamel C	Enamel A	Enamel B
0.5	0	0	0	3	0
1.0	1	0	0	10	0
2.0	5	100	0	20	....
3.0	20	100	0	35	....

Enamel A, the percent area dezinced increased with increasing oleic acid content. With Enamel B, no dezincing was observed at the 0.5% and 1.0% oleic acid levels; dezincing was not reported at the 2% and 3% levels in view of complete enamel peeling in these cases.

Sterile Process. As shown in Table 3, both oleoresinous C-type enecamels (Enamels A and B) exhibited approximately the same degree of failure on one of

TABLE 3

Effect of increasing oleic acid on enamel performance (Sterile process)

% Oleic Acid	% Blistering			% of Enamel Area Dezinced	
	Enamel A	Enamel B	Enamel C	Enamel A	Enamel B
0.5	6	4	0	20	38
1.0	20	20	0	38	35
2.0	20	20	3[1]	50	30
3.0	45	35	6[1]	70	38

[1] Ends only in area adjacent to anode.

three cans even at 0.5% oleic acid level. With cans having Enamel C, there was a trace of blistering of the enamel adjacent to the anode with oleic acid contents of 2% and 3%. Enamel failure in this case was in part attributed to the effect of the anode which had previously been proven the cause of enamel failure at high processing and storage temperatures. This will be discussed later. With Enamel A, the percent area dezinced increased with increasing oleic acid content; however, with Enamel B, dezincing was of approximately the same magnitude at all oleic acid levels.

Effects of phosphates on free fatty acids produced. Acid contents of the product at different stages are presented in Table 4. The addition of phosphate salts

TABLE 4

Effects of phosphates on free fatty acids produced during curing storage

Treatment	Percent Oleic Acid Produced[1]	
	Normal Cure	Phosphate Cure
Fat as received	0.81	0.75
After Cure	3.3	2.9
After Processing:		
1) Sterile Process	3.3	2.5
2) Non-sterile Process	2.9	3.2

[1] Free Fatty Acid content determined by Standard AOAC analysis and reported as Oleic Acid.

to the curing brine had no significant effect on the amount of free fatty acids produced by the fat during curing or processing.

Free fatty acid content of test pack and commercial hams. Free fatty acid analyses were made on samples of fat from 25 commercial test packs of phosphate cured hams packed in enameled cans with a sacrificial anode. The analyses showed a free fatty acid range of 0.2% to 1.2% with an average oleic acid content of 0.7%. No enamel failure was observed in any of these containers.

The first severe outbreak of enamel peeling in commercially canned phosphate cured hams occurred in April, 1956. Enamel failure was noted the day after the product was packed. A check of the free fatty acid content indicated the range of oleic acid content from 1.7% to 3.5%. The incidence of enamel failure and free fatty acid content of six commercial samples are given in Table 5.

TABLE 5

Relationship of free fatty acid content of canned hams to incidence of oleoresinous "C" enamel failure

Sample	Enamel Failure	% Oleic Acid
1	None	1.7
2	None	2.9
3	Severe peeling	3.1
4	Severe peeling	3.5
5	Slight peeling	2.7
6	None	2.9

Further tests on ham involved in incidents of peeling throughout the industry during April to July showed a range in free fatty acid content from 1% to 3.5%. Enamel failure ranged from small areas of severe softening to extensive blistering and peeling.

During these studies, three widely used oleoresinous "C" enamels were tested along with the pigmented enamel. Although occasions of enamel failure occurred with three commercially available "C" enamels, there was no evidence of failure with the pigmented enamel.

Analyses were run on ham throughout the year to determine nitrite, nitrate and phosphate content, as well as free fatty acid content. There was no correlation between variations in any of these, except between free fatty acid content and enamel failure. Enamel failure with the oleoresinous "C" enamels was most frequent during those months when hams from frozen storage were being packed. The worst incidence of failure involving commercial "C" enamels occurred with hams definitely known to have come from frozen storage.

Container requirements for sterile process canned hams. Canned hams of one and one-half pounds weight are given a sterile process in order that they may be stored at room temperature. The introduction of phosphate curing of hams necessitated container modifications in order to satisfactorily package the sterile-processed product.

Experimental packs were made in order to determine the necessity of using a sacrificial aluminum anode in containers for phosphate cured hams given a sterile process. Cans were packed with meat utilizing the various curing ingredients in combination or individually, and opened after one month's storage at

room temperature. The results of the container evaluations are presented in Table 6.

These data indicate that the use of a sacrificial anode with sterile-processed meat is detrimental to container performance, particularly as regards enamel performance. Some degree of enamel lifting or blistering was encountered in all cases when an anode was used in combination with a sterile process, whereas no enamel lifting occurred in the absence of the anode.

Regarding anode behavior, with the medium under test, namely sterile process phosphate cured or non-phosphate cured hams and attendant juices, aluminum is anodic to the enameled tin plate surface. Exposed iron, normally anodic to enameled tinplate is cathodic to the aluminum anode. Although the cathodic iron has

TABLE 6

Effect of curing ingredients and sacrificial anodes on container performance of sterile processed phosphate cured hams

Anode	Cure	Averaged Blistered Enamel Area Per Can[1] (sq. in.)
None	Standard Phosphate	0
Commercial Anode	Standard Phosphate	.625
Commercial Anode	Nitrite Only + Salt	.500
Commercial Anode	Nitrite Only + Salt	.500
Commercial Anode	Phosphate Only + Salt	.562
Commercial Anode	Salt Only	.312
Commercial Anode	Nitrite + Nitrate + Salt	.500
Commercial Anode	No Curing Agents (meat only)	Less than .068
Commercial Anode	Standard Phosphate + Ascorbic Acid	3.000

[1] Average of six cans of each variable.

less tendency to go into solution and cause product discoloration, it is also known that enamel blistering will occur at an enameled cathodic surface. Electrochemical activity increases as temperature increases, therefore, at higher processing or storage temperatures, there is a greater tendency for enamel blistering to occur. It is thus postulated that this increased activity with the sterile product results in formation of alkali and hydrogen gas at the enamel-tin coating interference at minute pores in the enamel film, thus causing enamel blisters.

Data presented in Table 6 show that none of the normal curing ingredients used, namely, sodium nitrate, sodium nitrite, sodium tripolyphosphate, or salt, had any excessive accelerating effect on enamel blistering; however, meat canned without any curing ingredient showed considerably less enamel blistering. In the presence of an anode, addition of ascorbic acid to the curing ingredients actually accelerated enamel blistering. It is possible that ascorbic acid is contributory to enamel softening, or that it accelerated corrosion of the aluminum anode, thus increasing the incidence of enamel blistering.

Results of these experimental packs showed that the use of a sacrificial aluminum anode was not required for phosphate cured sterile-processed canned hams, and that it actually would be detrimental to container performance. The experimental results were later confirmed with large scale commercial packs of sterile-processed phosphate cured hams. These commercial test packs without anodes also demonstrated the superiority of the pigmented enamel (Enamel C) for use with the sterile processed phosphate cured hams over the oleoresinous C-type enamels.

SUMMARY AND CONCLUSIONS

Addition of phosphate to the curing ingredients of canned pork products presented various container problems not previously encountered with conventional curing methods. Various aspects of these packaging engineering problems were subsequently studied extensively through experimental test packs and commercial packs in order to develop and establish container specifications for phosphate cured meat products. Results of these investigations are summarized below:

1. Failure of oleoresinous C-type enamels increased with increasing oleic acid content with both non-sterile and sterile-processed phosphate cured products. No failure of the pigmented enamel occurred with increasing oleic acid content of non-sterile processed phosphate cured products.
2. Addition of phosphate salts to the curing brine had no significant effect on the amount of free fatty acid produced by the fat during curing or processing of the pork product.
3. Analyses of samples of fat from 25 commercial packs of phosphate cured hams showed a free fatty acid range of 0.2% to 1.2% with an average oleic acid content of 0.7%. No enamel peeling was observed in any of these containers. Subsequent product analyses and container evaluations of commercial packs showed that as the oleic acid content increased the incidence of enamel peeling also increased. It was observed that enamel failure was most frequent when hams from frozen storage were canned.
4. In establishing container requirements for sterile-processed, phosphate cured hams it was found that:
   (a) a sacrificial anode was actually detrimental to container performance, particularly as regards performance of the enamels tested.
   (b) none of the normal curing ingredients such as sodium nitrate, sodium nitrite, sodium chloride or sodium tripolyphosphate had an excessive accelerating effect on enamel blistering. In the presence of an anode some degree of enamel blistering was encountered with each curing ingredient variable. Addition of ascorbic acid to the curing ingredients, in the presenec of an anode, accelerated enamel blistering.
   (c) experimental results showed that a sacrificial anode was not required for phosphate cured sterile-processed ham cans; these findings were later confirmed by commercial packs.
   (d) commercial packs without anodes also dem-

onstrated the superiority of a pigmented enamel over the oleoresinous C-type enamels for sterile-processed, phosphate cured hams.

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Relative Efficacy of Three Tetracyclines with Poultry Meat[a, b]

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The present study was undertaken to determine the relative efficiencies of the tetracycline group of antibiotics in extending the storage life of dressed poultry meat. Ziegler and Stadelman *(7)*, Kohler *et al. (3)*, and Ayres *et al. (2)* have reported on the extension of storage time by the use of chlortetracycline in concentrations from one to 270 p.p.m.

Ziegler and Stadelman *(7)* immersed chilled half chickens in water solution containing 0, 10, 20 and 40 p.p.m. chlortetracycline. Stored at 2.2° C. these treatments resulted in storage times of 11.6, 17.6, 18.4, and 18.9 days respectively before the development of off odor was detected. Kohler *et al. (3)* using whole or cut up birds reported that the poultry meats which received antibiotic treatment at 10 and 30 p.p.m. remained unspoiled considerably longer than the untreated meat. Ayres *et al. (2)* reported that at levels of 3 or 10 p.p.m. chlortetracycline was the most effective of a number of antibiotics tested for prolonging the storage life of chickens stored at 4.4° C. Oxytetracycline was found to be second in order of effectiveness. In studies made on the development of slime and the associated microflora Ayres *et al. (1)* reported the predominant bacteria present at the time of spoilage to be *Pseudomonas-Achromabacter* types. This observation was also made by Walker and Ayres *(4)* from studies on the kinds of microorganisms associated with commercially dressed poultry. That treatment with antibiotics of the tetracycline group at 4.4° C. has a marked effect on storage life but a lesser effect on the predominant organisms occurring at time of spoilage was shown by Ayres *et al. (2)*. His study showed that at the time birds developed off odor and slime the *Pseudomonas-Achromabacter* types accounted for 90 to 95% of the total population. An increase in the development of yeasts was noted on the chlortetracycline treated birds. Other studies by Wells and Stadelman *(5)* have shown that if the storage time of the chlortetracycline treated poultry is greater than 12 days the number of yeasts is greatly increased. At 3° C. slightly over 25% of the spoiled chickens may show a predominant yeast flora if the effectiveness of the antibiotic is sufficient to allow a storage life of nearly 18 days.

EXPERIMENTAL METHODS

Antibiotics used in this study were chlortetracycline (CTC), oxytetracycline (OTC) and tetracycline (TC). All three were used at a level of 10 p.p.m.

Chickens were obtained from the Purdue poultry farm and brought to the poultry processing building for dressing. They were killed by slashing the throat. After a one-minute bleed out time they were scalded in water at 60° C. for 40 seconds. Picking was done on a mechanical picker. The birds were eviscerated, halved, and chilled in ice. After chilling the half birds were treated with the respective antibiotics by placing them in cooled water solutions containing 10 p.p.m. of the antibiotic. The chickens were kept in the antibiotic solutions (or water) for 15 minutes. They were then removed, allowed to drain, and packaged. Packaging consisted of placing the half chicken

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in an absorbent cardboard tray and placing the chicken and tray in a polyethylene bag. Four halves were used for each treatment at each temperature level. Three replications were made. In addition to the 3 replications made at the University plant, one such experiment was done at a small commercial plant.

Four halves of each treatment were stored at each of 4 temperatures: 0° C., 3° C., 9° C. and 12° C. Spoilage was determined by the development of odor and slime. In addition, the smear method of Ziegler *et al. (8)* was used to follow the development of microbial increases and changes occurring during the storage period.

One bird from each treatment group at each temperature level was taken at the time of spoilage and platings made of the skin surfaces. The swab technique was used. Enumeration of the microorganisms present was made on nutrient agar incubated at 20° C. for 3 days.

RESULTS AND DISCUSSION

Chlortetracycline (CTC) was found to be the most effective of the 3 antibiotics used as a dip at all of the storage temperatures used. Results might have been modified by using the commercial preparations of CTC and OTC in that uptake of the antibiotics might vary due to carriers used in the commercial preparations. Results might be further modified by using the antibiotics in the cooling medium with resultant 2 to 4 hour exposure to the antibiotic solution. Results of Ziegler *(6)* indicate little or no difference due to the latter possibility using CTC. Information using OTC and TC is not available.

At 0° C. an average storage time of 17.1 days was (Table 1) needed before odor and slime development

TABLE 1

Average number of days to development of odor and slime

Treatment	0° C.	3° C.	9° C.	12° C.
None	10.8	10.9	5.5	5.4
10 ppm CTC	17.1	17.6	7.7	7.0
10 ppm OTC	13.7	13.5	7.1	6.8
10 ppm TC	14.0	15.2	6.6	6.0

were observed. This development of odor and slime occurred at 17.6, 7.7 and 7.0 days with storage temperatures of 3° C., 9° C., and 12° C., respectively. There did not appear to be any real differences in the results obtained by using either oxytetracycline or tetracycline. With the exception of the difference at 3° C. the results are practically the same for the two antibiotics.

From Table 2 it can be seen that there is little increase in storage life by reducing the temperature from 12° to 9° C. (2%). However, by reducing the temperature from 12° to either 0° or 3° C. a 100% increase results. From further study of Table 2 it is seen that there is a difference of 23% between the shelf life obtained with CTC over TC and an increase of 14% over that obtained with OTC when the temperature is reduced from 12° C. to 9° C. As storage temperature reduction increases these percentage differences also increased. Treatment with CTC and temperature reduction from 12° to 3° C. resulted in a 45% increase for the CTC treated birds over that obtained by TC treatment with identical temperature reduction and a 76% increase over the OTC treated halves under similar conditions.

The amount of storage life which could be attributed to antibiotic action alone was figured as the difference between shelf life of untreated birds (at a given temperature) and the shelf life of the antibiotic treated birds. It appears that with CTC treatment the effect is enhanced by lowering the storage temperature (Table 3). At 12° C., CTC treatment results in an increase in storage time (over that due to temperature) of nearly 30%. At 0° and 3° the increase obtained over that resulting from lower temperature storage is about 60%.

TABLE 2

Per cent increase in storage life due to combined antibiotic effect and temperature reduction (12° C. storage temperature used as 0% base)

	Temperature reduced from 12° C. to:		
Controls (Tempt. effect only)	0°	3°	9°
	100	100	2
+ 10 ppm CTC	217	226	45
+ 10 ppm OTC	154	150	31
+ 10 ppm TC	159	181	22

TABLE 3

Per cent increase in storage life due to antibiotics at various temperatures

	0° C.	3° C.	9° C.	12° C.
CTC	58.3	61.4	40.0	29.6
OTC	26.8	23.8	29.0	25.9
TC	29.5	39.4	20.0	11.1

The effectiveness of oxytetracycline does not appear to be increased by storage at the lower temperatures. The amount of increase due to antibiotic action was practically the same at all storage temperatures. The average per cent increase at 0° and 3° C. would be near 25% and this is almost identical to that obtained at 12° C. storage.

There appeared to be a tendency for a larger increase of storage time, by antibiotic action, at 3° C. when treatment was with tetracycline (Table 3).

These results seem to show that at 0° or 3° C. chlortetracycline is somewhere near 35% more effective than OTC and 25% more effective than TC.

TABLE 4

Average days to development of slime and odor (commercially dressed)

Treatment	0° C.	3° C.	9° C.	12° C.
None	8.0	6.0	3.0	3.0
10 ppm CTC	12.5	8.8	6.0	5.3
10 ppm OTC	10.0	7.0	3.0	3.0
10 ppm TC	12.0	6.8	5.0	3.0

Differences in storage times were noticed between the birds processed in the small commercial plant and those dressed in the University plant (Table 4). In all treatments and with the untreated birds, the time to development of odor and slime was less. As was

found with the University dressed birds chlortetracycline gave the greatest extension of storage time at all temperatures.

In so far as colonial pigmentation and microscopic examination can be used as criteria, an examination of the colonies developing on the agar plates showed that a greater proportion of the microflora developing on these birds were similar to *Flavobacterium*, and at 9° and 12° C. over 50% of the colonies found on the nutrient agar plates were of this type. Chromogenic colonies were of little significance on the birds processed at the University plant. On the birds processed at both the University and the commercial plant yeast development on the antibiotic treated birds became of more consequence. On some of the CTC treated birds a predominantly yeast flora was observed at spoilage.

It would appear then that the storage life of dressed poultry depends upon a combination of many factors. Some of these are the temperature of storage, the antibiotic used, the degree of total contamination of the poultry meat, the relative numbers of the various types present, the pattern of the ascendency of types under the various storage temperatures and under the conditions created by the combined effects of storage temperature and antibiotic treatment. It is also seen that when all these factors are considered that of the 3 tetracyclines, chlortetracycline used as a dip solution is more effective in delaying the development of bacterial growth on poultry meat held at temperatures under 12° C.

SUMMARY

The effect of dipping eviscerated poultry in three tetracycline antibiotics and storing at temperatures from 12° C. to 0° C. was tested.

Under all the conditions imposed chlortetracycline (CTC) was more effective in prolonging storage time than either oxytetracycline or tetracycline. At 3° C. the per cent of the total storage time attributed to the action of CTC was 61.4%. For oxytetracycline at this temperature it was 23.8% and for tetracycline 39.4%.

With poultry processed at a small commercial plant an increase in the number of organisms belonging to the *Flavobacterium* group was noticed at temperatures of 9° and 12° C.

Increases in yeasts were observed on the antibiotic treated birds.

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Application of Statistical Quality Control Procedures to the Canning of Green Beans[a, b]

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As with any operation for the control of quality of a manufactured article, statistical quality control of canned green beans requires the drawing of adequate samples in accordance with a prescribed design, inspection of these samples by reliable test procedures, and a statistical evaluation and posting of these test results. Such tests may be carried out on the raw materials and supplies, process variables, and, finally, on the finished product.

RAW MATERIAL CONTROL

Green beans are conveyed to the processing plant by truck in bushel hampers or pallet crates containing approximately 30 and 200 pounds of beans, respectively. Loads may vary from 200 to more than 1,000 hampers, or from several to 60 pallet crates. A sampling schedule is shown in Table 1, indicating how many beans out of how many crates or hampers should be drawn, depending upon the size of the load. This schedule is based on attributes criteria on the order of military standard 105A *(7)*, where sample size is increased with increasing lot size in order to obtain greater accuracy where larger lots are involved. The reduction in error, as sample size is increased, is shown in Table 2 for the seed and shear-press determinations.

TABLE 1

A sampling schedule for loads of green beans for processing

Number of crates or hampers in load	Number of crates or hampers to be sampled	Pounds of beans to be drawn from each		Total pounds to be drawn from load of	
		hamper	*crate*	*hampers*	*crates*
Up to 15	2	5	15	10	30
16 to 40	3	7	15	20	45
41 to 65	5	6	12	30	60
66 to 110	7	6	10	40	70
111 to 180	10	5	8	50	80
181 to 300	15	4	6	60	90
300 to 500	25	3	4	70	100

The beans within each container, as well as the containers from which the sample is to be drawn, are to be selected completely at random. If, however, there is a reason to believe that the quality of different parts of the load varies significantly, then each such part should be sampled separately as an individual lot, with random selection of samples within each lot.

TABLE 2

Reduction in the sampling error as sample size is increased (Error in terms of ±2 sigmas, or 95% confidence level. Based on data from 35 loads.)

Size of sample, lbs.	Sampling error		
	% seed	Shear-Press lbs. force	% fiber equivalent
10	2.3	62	.03
20	1.7	44	.03
30	1.3	35	.02
40	1.1	30	.02
50		27	.02
60	.9	25	.01
70	.8	23	.01
80	.8	21	.01
90	.7	20	.01
100	.7	19	.01

Factors of quality requiring evaluation are size, defects, maturity, and fiber. Only the first two factors are covered with any degree of adequacy by U. S. standards *(8)*. The factor of maturity, however, as measured by seed development and fiber development are included in Food and Drug standards of quality so that compliance with these standards is not only advisable, but mandatory *(1)*.

Size is measured in terms of the narrower pod diameter as follows:

Sieve size	Diameter in 64th inches
1	Less than 14½
2	14½ to 18½
3	18½ to 21
4	21 to 24
5	24 to 27
6	27 or more

The defect factor refers to the presence of extraneous vegetable matter, poor workmanship such as ragged cut, mechanical damage, insect or disease injury.

Per cent seeds, or the ratio of seed weight to pod weight, is a major indication of green bean maturity. The following grade limits have been suggested for this quality factor: fancy—up to 8% seed; extra standard—8.1 to 18.0; standard—18.1 to 25.0; and sub-standard—over 25.0. The sub-standard limit is

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[b] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 15, 1957.

mandatory for canned green beans. For whole canned beans, seed of raw beans is practically identical to the canned *(4)*. French style beans tend to have a lower per cent seed than the original raw material, depending on how the beans are handled.

Per cent fiber may be determined by the official Food and Drug procedure where a mandatory requirement of not more than 0.15% is necessary for packs that are to be labeled as better than sub-standard *(1)*. A more rapid blender method is available *(5)*. Both of these methods, however, involve laboratory procedures and a time lapse before results are available. Recently an instrumental method was developed, utilizing the Shear-Press which is closely correlated with fiber content and requires less than one minute for its completion *(6)*.

In order to cover all of these important factors of quality, the following test procedure is suggested:

1. The entire sample, drawn in accordance with the schedule shown in Table 1, is put through a sample sizer and the weights of the different sizes as well as the trash noted. Remaining tests may be made on field run samples or on one or more of the individual sieve sizes depending on what is to be done with the beans subsequently.
2. A 300-g. sample of the beans is then weighed and number and/or weight of defective beans noted.
3. The beans are then snipped and slitted and the seed collected and weighed in order to obtain the per cent seed determination.
4. The snipped de-seeded pods are then cut to 2½ inches and placed in the standard cell of the Shear-Press perpendicularly to the slits. One hundred grams of these pods are placed for each determination and the pounds of force required to shear through this sample noted. Ordinarily, there is more than adequate material to run the Shear-Press determination in duplicate.
5. Results of these determinations may be posted on control sharts such as those shown in Figure 1. Procedures for determining control limits on these charts may be found in a number of references *(2, 3)*.

PROCESS CONTROL

Many plant operations required for the manufacture of canned green beans may benefit from the application of statistical quality control. It is up to management to determine what points in the operation would justify the construction and maintenance of control charts. This discussion will be limited to snipping and filling operations, two applications which would return substantial dividends.

Snipping. Samples may be collected continuously in a suitable container, such as a Number 10 can, at the end of each snipper belt, and the contents examined at regular intervals, preferably every 15 to 20 minutes. The examination of the contents should be made by an inspector who should vary his itinerary

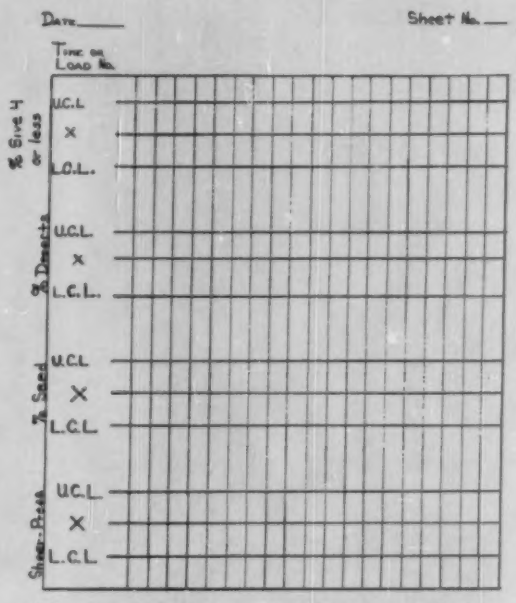

Figure 1. Green beans control chart, raw product.

sufficiently so that the workers on each belt would not know exactly when the inspector is due. The number of unsnipped beans can be recorded on a "C" chart *(2)*. It may be advisable for the same inspector to make an inspection of defects at the same time. It may not be necessary to check each belt separately; however, if a check is made only on the composite sample it will be more difficult to trace back a high snip count to the specific snipper and belt that is out of control.

Fill. Dramatic savings may be expected by the use of quality control charts on hand-filling operations of French style beans. Studies made in several processing plants indicated savings of up to 12% of material and at the same time a reduction in number of underfilled cans. As in the case of the snippers, maximum results may be obtained only when attention is given to individual fillers who in this case are individual operators. It is suggested that each operator be checked at 30-minute intervals. At each check, 5 cans are to be weighed and the average and range values posted. Data in Figure 2 show results obtained on one filling line as a consequence of application of control charts.

FINISHED PRODUCT CONTROL

One important benefit of a thorough quality control program on the raw material and on plant operations is that the finished product may be labeled and packed immediately rather than await a finished quality report in order to decide on the label which is to be used. However, even under ideal circumstances it would be advisable to inspect the finished product, though at a greatly reduced frequency. Where U. S. standards for grades are used the data obtained on the finished product may be posted on

control charts such as those shown in Figure 3. Where other criteria are used to establish the quality level of the finished product, the procedures and control charts may be modified accordingly.

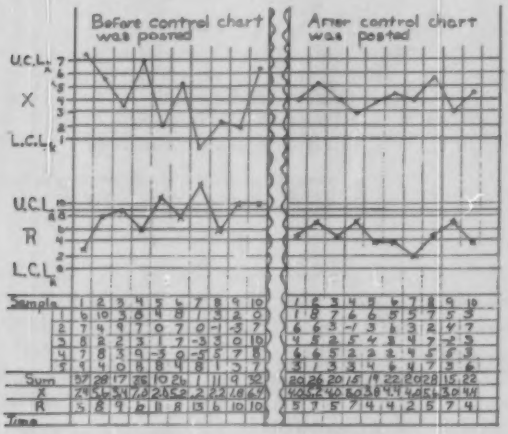

Figure 2. Control chart for fill of container in eighths ounces above 4.0 ounce minimum.

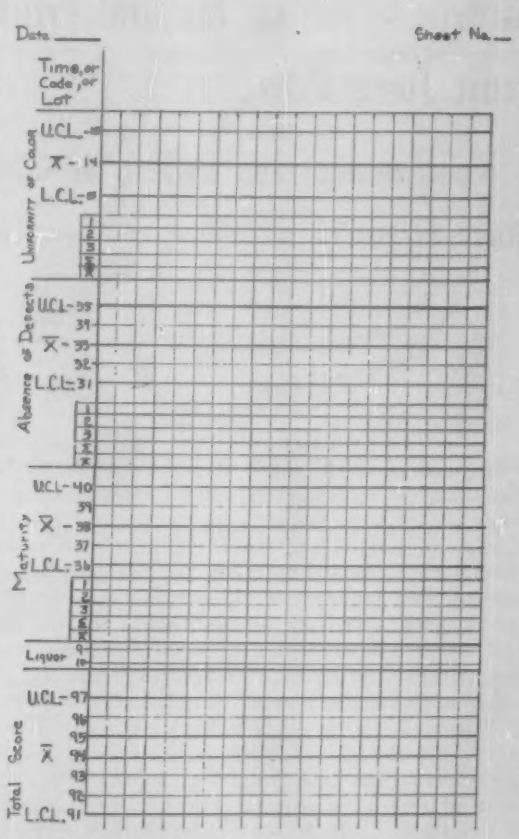

Figure 3. Green beans control chart, canned product.

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Incorporation of Natural Fruit Flavors Into Fruit Juice Powders

II. Concentration and Locking of Concord Grape Flavor[a]

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(Manuscript received May 22, 1957)

RESEARCH AND DEVELOPMENT of fruit juice powders at the Western Utilization Research and Development Division during the past 5 years has led to methods for preparation of powders of superior quality and stability *(11, 15, 16)*. Coincidental with this development has been research on methods for preparation of natural volatile fruit flavors in suitable form for addition to the powders. This addition is essential for making powders which reconstitute to palatable, full flavored juices. At this Laboratory, stabilization of the volatile flavor is done by "locking" it in an edible, water-soluble, solid carrier. Methods used for locking citrus oils (cold-pressed from the peel) for incorporation with citrus juice powders have been described in the first paper of this series *(14)*. In our earlier work, sorbitol *(7)* was used as the carrier, but more recently we have used dextrose and sucrose and have found various sugar mixtures to be superior locking agents *(14)*.

In the case of Concord grape and many other non-citrus fruits, the volatile flavor cannot be obtained directly in a non-aqueous form as are the citrus oils. The volatile flavor must be recovered from the juice *(2, 10)* and highly concentrated to a non-aqueous form before it is locked. Recovery of the volatile flavors from a number of different fruit products is practiced commercially. In a paper from this Laboratory *(6)* it was shown that recovered volatile flavor constituents of strawberry and apple juices can be concentrated in the overhead fraction from a continuous distillation column without appreciable loss or change in flavor. Even constituents which have boiling points much higher than that of water are concentrated in the overhead fraction. Success of this method depends upon azeotropic behavior of the constituent with water. These procedures as well as the procedure for further concentration by solvent extraction are discussed by one of the authors *(4, 5)*.

The identity of the important volatile flavor constituents of Concord grape juice is not known, though methyl anthranilate and other esters have been implicated. A recent contribution to this subject has been made by Holley and co-workers *(9)*. In addition to 8 identified volatile constituents (all low-boiling except methyl anthranilate and acetic acid and of doubtful importance flavorwise) they found an unidentified oil which was important with regard to flavor although it amounted to less than 1% of the volatile organic component (excluding ethanol). They also found that ethyl acetate (mostly) and methyl acetate accounted for over 95% of the volatile esters.

The present paper describes experiments on recovery of the volatile flavor from Concord grape juice, concentration of the flavor by distillation and extraction, and locking of the concentrated flavor in solid carriers. Analytical data on total volatile esters and methyl anthranilate were obtained to indicate the degree of recovery of both low-boiling and high-boiling constituents in each of the processing steps.

EVALUATION METHODS

Chemical procedures. Total volatile esters were estimated by a modification *(13)* of the method of Thompson *(18)*. In this method the esters were converted by hydroxylamine to hydroxamic acids, and the red complex which the latter formed with ferric ion was determined colorimetrically. Methyl anthranilate was estimated by the official colorimetric method of the AOAC *(1)*. Each of the analyses was run on a portion of 300 ml. of aqueous distillate obtained by steam distillation of 100 ml. of sample or diluted sample. In cases where the sample itself was a distillate, the distillation step of the analytical procedure was omitted. Results obtained on duplicate samples usually did not vary more than plus or minus 5% from the average value except when the ester or methyl anthranilate concentration in the sample was lower than in the original grape juice.

Organoleptic methods. Samples taken at the various stages of flavor concentration were prepared for organoleptic evaluation by dilution back to single strength (except in one series noted otherwise). This was done by mixing equivalent portions of flavor and reconstituted grape juice concentrate, or powder, without regard for losses of volatile flavoring constituents which might be inferred from the chemical data. In a few cases a synthetic medium consisting of 10% sucrose, 0.5% citric acid, 0.5% sodium citrate and 89% water was substituted for the reconstituted juice. Comparison of flavors was usually made by the triangle method *(8)* with a panel of about 10 trained judges. In such tests the judges were allowed to test the samples by aroma, flavor, or both. A paired comparison was used in one series of tests. In this procedure the judges were required to select the sample with more pronounced

[a] Presented at the Fourteenth Annual Meeting of the IFT, Los Angeles, Calif., June, 1954.

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grape aroma. Other comparisons were made informally; coded samples were used and the judges independently made their comments on strength of natural aroma and flavor and on any other points of interest.

RECOVERY AND CONCENTRATION OF GRAPE FLAVOR

The steps in our experimental process of flavor concentration are shown schematically in Figure 1, along with other steps required for producing full-flavored grape juice powder. Analytical data showing the recovery or retention of volatile esters and methyl anthranilate are shown in Table 1, which is arranged in 4 steps to correspond to the information given in the text below. Organoleptic evaluations of the various samples are summarized in Table 2.

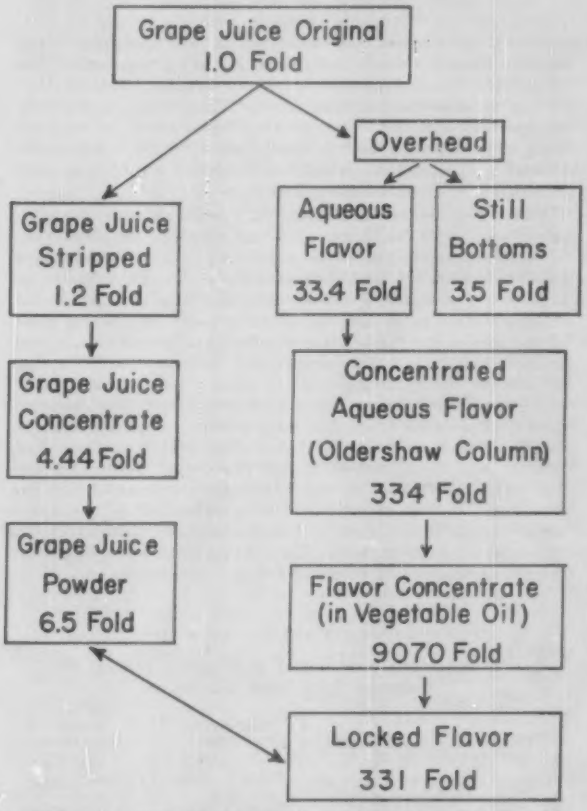

Figure 1. Steps in the experimental process of flavor concentration.

Recovery and first step of concentration. Recovery of the volatile flavor from 430 gallons (3,786 lbs.) of Concord grape juice was accomplished in equipment of pilot-plant scale *(2)*. The juice was continuously fed at about 75 gallons per hour into a steam-injection heater and tubular evaporator, where vapor amounting to 27% of the steam-heated juice was removed by flash vaporization. The vapor passed directly into a five-foot rectifying column, packed with raschig rings, where the flavoring material was concentrated and taken off in the overhead fraction. This operation yielded 13.6 gal. (113.2 lbs.) of 33.4-fold [4] aqueous flavor solution. The recovery of total volatile esters in this fraction was 75%, while the recovery of methyl anthranilate was only 16% (Table 1, line b).

[4] The fold number as used in this paper is the ratio of weight of original juice to weight of corresponding flavor concentrate (or other product). The fold number may or may not represent the factor by which the concentration of flavoring material is increased, depending on sharpness of separation and freedom from losses.

TABLE 1

Total volatile esters and methyl anthranilate content of concord grape juice, fractions, and products from representative experiments

Step in process and substance	Fold No.	Total volatile esters [1]		Methyl anthranilate	
		Actual	88 Basis [2]	Actual	88 Basis [2]
		p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*
a. Original juice	1	42	42	1.9	1.9
STEP ONE: *Flavor recovery:*					
b. Aqueous flavor	33.4	1,070	32	9.9	0.30
c. Stripped juice	1.19	4	3.2	1.3	1.1
d. Raschig ring col. bottoms	3.54	16	4.6	0.9	0.3
STEP TWO: *Continuous distillation:*					
e. Concd. aqueous flavor	334	9,200	28	95	0.29
f. Oldershaw col. bottoms	~33	~10	~0.3	<0.08	<0.003
STEP THREE: *Flavor extraction:*					
g. Concd. flavor in rice oil	9,070	130,000	14	2,600	0.29
h. Aqueous residue, 1st extn	—	—	2.1	—	—
i. Aqueous residue, 2nd extn	—	—	0.5	—	0.003
j Iso-pentane distillate	—	—	~10	—	—
STEP FOUR: *Locking:*					
k. Locked flavor in sucrose	331	820	2.5	77	0.23
l. Locked flavor in sorbitol [3]	675	1,850	2.7	180	0.27

[1] Expressed as ethyl acetate.
[2] Single strength basis.
[3] Starting material was a 14,000 fold flavor concentrate (in rice oil). Analysis showed 2.6 p.p.m. total volatile esters and 0.31 p.p.m. methyl anthranilate (both on ss. basis).

To determine possible heat damage or loss of flavor, equivalent portions of the 33-fold flavor solution and stripped juice were combined and diluted to single strength and compared organoleptically with a sample of the original juice. No difference in flavor was detected (Table 2, test 1). This finding indicates that there was no appreciable heat damage during the flavor recovery process and that loss of flavoring constituents in the column bottoms was not serious.

Evidence that the 33-fold aqueous flavor solution contained important flavoring constituents in considerable concentration is shown in two experiments: (a) The flavor solution added at one-half the equivalent amount to reconstituted concentrate was compared with the reconstituted concentrate without added flavor. As shown in Table 2, test 2, 94% of the responses were correct, and preference in a similar experiment was 20 to 3 in favor of the juice with added flavor. (b) Other organoleptic comparisons of reconstituted grape juice concentrate, with and without added 33-fold flavor, were made with progressive further reduction of the amount of added flavor below the equivalent amount. The paired-test method was used. The results were significant, at the 1% level, of detection of the added flavor down to 2.5% of the equivalent amount (0.75 ml. of 33-fold flavor solution per liter of reconstituted juice).

The 33-fold flavor solution was divided into several portions for further concentration by different experimental procedures with laboratory-scale equipment. An account of the more important of these experiments is given in the sections that follow.

A portion of the stripped juice was concentrated to 62° Brix in a vacuum pan evaporator at 80° F., and a portion of the resultant concentrate was puff-dried in a vacuum shelf drier. The grape-juice concentrate and powder contained about 30 and 25%, respectively, of the methyl anthranilate present in

TABLE 2

Organoleptic evaluation of Concord grape flavors—triangle method

Test	Flavors under comparison [1]		Medium	No. of judgments	Percentage of correct responses
	1	2			
1	33-fold, aqueous (1b) and stripped juice (1c)	vs. Original juice (1a)		41	37
2	33-fold, aqueous (1b) (0.5 single strength)	vs. No added flavor	Reconst'd. Conc't.	33	94
3	330-fold, continuous distn. (1e)	vs. 33-fold, aqueous (1b)	Sugar-acid soln.	15	20
4	Fractions 1 and 2, batch distn. (3b, c)	vs. 33-fold, aqueous (1b)	Sugar-acid soln.	25	44
5	Fraction 2, batch distn. (3c)	vs. 33-fold, aqueous (1b)	Reconst'd. Conc't.	47	43
6	Fraction 2, batch distn. (3c)	vs. Fractions 1 & 2 (3b, c)	Reconst'd. Conc't.	46	52
7	9070-fold, in rice oil (1g)	vs. 33-fold, aqueous (1b)	Reconst'd. Conc't.	48	67
8	Locked in sorbitol (1f)	vs. 33-fold, aqueous (1b)	Reconst'd. powder	38	50

[1] Letters in parentheses refer to Tables 1 and 3.

an equivalent amount of the original juice. The loss of this ester, with the water evaporated from the juice after the flavor recovery step, was about 40%.

Second step of concentration. An all-glass, one-inch, Oldershaw-type distillation column with 40 plates *(6)* was used for the second step of flavor concentration. This unit was operated at atmosphere pressure, either batch-wise or continuously.

In a typical continuous run, 5 liters of the 33-fold aqueous flavor was fed into the column at the twentieth plate at about 900 ml. per hour. The rate of take-off of overhead fraction was about 8.5% of the feed rate. It was estimated that the average residence time of the flavoring constituents in the column was about 10 minutes. The total weight of distillate, including that received while stripping the column after the feed was stopped, was 500 g. Thus the fold number of this concentrated aqueous flavor solution was 334. Chemical analysis indicated that nearly all of the methyl anthranilate and esters were present in the distillate, with losses in the bottoms in the order of 1% or less (Table 1, lines e and f). No difference in flavor was detected between feed and distillate (Table 2, test 3). The sugar-acid solution was used to minimize background aromas and thereby increase the sensitivity of the panel to any flavor differences. These results indicate that recovered volatile flavoring constituents of Concord grape juice can be further concentrated by continuous distillation at atmospheric pressure without development of off-flavor or loss of natural flavor. This is also in agreement with findings on volatile strawberry and apple flavors *(6)*.

Batch distillation. Although the investigators are of the opinion that continuous operation is to be preferred, this section on batch-wise distillation is included because it gave more information on the nature of the volatile constituents. In a typical run, 12.9 liters of the 33-fold aqueous flavor was boiled in a 22-liter flask at the bottom of the column, with heat from a glass col mantle. Only the 25-plate section of the column was used. The first fraction, distilling range 78–80° C., amounted to 163 ml. (130 g.). Practically no distillate was obtained between 80° and 95° C. The second and final fraction, distilling range 95–100° C., was arbitrarily cut at about 830 ml. and made up to one liter. The first fraction contained about 90% of the esters in the starting material (Table 3, line b). The second fraction contained only about 2% of the esters but about 75% of the methyl anthranilate (Table 3, line c). About 20% of the methyl anthranilate was found in the still bottoms.

These results indicate that most of the ester material is low boiling, with volatility near that of ethyl acetate. This conclusion is in agreement with the findings of Holley and coworkers *(9)*. The actual ester content of fraction 1 was about 9%. The remainder was presumed to be mainly ethanol, from the density, boiling range, and the fact that considerable ethanol has been reported in the volatile fraction of Concord grape juice *(9)*.

Fractions 1 and 2 combined and fraction 2 alone were separately compared organoleptically with the 33-fold aqueous flavor solution (Table 2, tests 4, 5). The results indicated that there was little flavor difference, if any, in either test. It was thought that fraction 2 alone (the high boiling fraction) might contain all of the important flavoring constituents. However, a difference, significant at the 1% level, was found between fraction 2 alone and fractions 1 and 2 together (Table 2, test 6). These findings lead one to conclude that the low-boiling constituents, including most of the esters, are relatively unimportant but that some or all of them may be required along with the high boiling constituents for flavoring reconstituted grape juice concentrate or powder to a quality as near as possible to that of fresh grape juice.

Third step of concentration. Extraction of the flavoring constituents with iso-pentane was employed as the third step of flavor concentration. This method appears to be the most feasible method for final concentration of the the flavor to an oil. Such a non-aqueous flavor concentrate is required in the locking method used, since water would lower the melting point of the carrier too far or make it sticky and promote undesired crystallization *(14)*. Iso-pentane was chosen as the extracting solvent for the following reasons: first, its low boiling point which facilitates its subsequent removal from the flavoring constituents; second, its lack of tendency to form peroxides, as ether does; and third, its selective solvent action. Iso-pentane was found to extract the esters, and presumably any less water-soluble constituents which might be present, but not to detectably extract ethanol, which amounted to about ten times the quantity of other volatile organic material in the concentrated aqueous flavor. The aqueous layer remaining after extraction was devoid of grape aroma.

TABLE 3

Volatile esters and methyl anthranilate content of fractions from batch distillation

Fraction	Fold No.	Total volatile esters		Methyl Anthranilate	
		Actual	SS basis	Actual	SS basis
		p.p.m.	p.p.m.	p.p.m.	p.p.m.
a. Aqueous flavor	33.4	1,070	32	9.9	0.30
b. Concd. flavor, fraction No. 1	3,320	89,000	27	<3	<0.001
c. Concd. aq. flavor, fraction No. 2	431	250	0.6	98	0.23
d. Oldershaw col. bottoms	36	13	0.4	2.2	0.06

Since the amount of flavoring component was small, and some of the constituents quite volatile, it was considered advantageous to add an edible, high-boiling, water-insoluble extender to the extract before boiling off the iso-pentane. Vegetable oils were chosen as extenders because of their unquestioned edibility, but other liquids under consideration may prove to have certain advantages. We have used rice oil and sesame oil. The latter is reported to have high stability *(3)*.

Apparatus used for the extraction experiments was an all-glass liquid extractor of the Palkin automatic type *(12)*. Our unit was modified by including a distillation column 7 inches long, packed with glass helices, between the extract flask and the condenser and a fritted glass plate for breaking up the

condensed solvent into fine globules in the aqueous phase. After extraction was complete a 14-inch helix-packed column was used for distilling off the solvent from the extract. Although iso-pentane boils at only 27° C., it was found that over 90% of the esters were lost by vaporization unless a rectifying column was used.

In a typical extraction experiment, 250 g. of 330-fold concentrated aqueous flavor was extracted overnight with 100 ml. of iso-pentane. The extract was transferred and extraction continued over the second night with 100 ml. of fresh iso-pentane. The extracts were combined, 5.0 g. of rice oil was added, and the iso-pentane was distilled off. This operation yielded 9.20 g. of 9,070-fold flavor concentrate. Essentially all of the methyl anthranilate but only about half of the total volatile esters was extracted and retained in the oil (Table 1, line g). The aqueous residue contained only about 2% of the esters. The iso-pentane distillate accounted for most of the loss, indicating that a more efficient fractionating procedure should be used for good retention of low-boiling constituents. A difference in flavor was found between the 9,070-fold flavor concentrate (in rice oil) and the 33-fold aqueous flavor (Table 2, test 7). It was not determined whether this difference was due to loss of low-boiling constituents or to some other cause.

Locking. The flavor concentrates (in vegetable oil) were locked by methods similar to those used for orange oil *(14)*. The following example illustrates the best procedure used. One hundred grams of sucrose, 50 g. of corn sirup (55% dextrose equivalent), and 25 g. of water were mixed in a 250-ml. beaker provided with a motor-driven stirrer and heated to boiling over a bunsen flame. Water was boiled off until the temperature reached 302° F. After the mixture had cooled to 248° F. the speed of the stirrer was increased and 6.4 g. of grape flavor concentrate (in sesame oil, 7,480-fold) was added dropwise in the vortex over a period of 2 min. Stirring was continued half a minute, while a spatula was used to direct the whirling mass toward the center. The emulsion was then poured on a stainless steel sheet. After cooling and hardening at low humidity (5–10% RH), the product was ground in a mortar and screened in such a manner as to yield as much as possible in a 10- to 20-mesh fraction. This fraction was evacuated for 20 hrs. Finally, the product was placed in a tightly covered jar with a small bag of desiccant *(17)*.

In the example above and similar experiments (e.g. Table 1, line k) 75–90% of the methyl anthranilate but only 10–20% of the total volatile esters present in the flavor concentrate (in vegetable oil) were found in the locked product.

The fold number of the described preparation was 321. Thus 3.12 g. (1,000/321) of this locked flavor is sufficient to make 1,000 g. (approx. 1 qt.) of reconstituted grape juice. The quality of the flavor of juice prepared at this concentration was compared informally with a portion of the same reconstituted juice without added flavor. Of 16 judgments (on two different days) there were 12 comments which favored the juice made with locked flavor as having more grape flavor than the plain juice, which was generally noted to be flat or weak in flavor. Three of the comments indicated the reverse. On the second day another portion of the reconstituted juice, flavored with 33-fold aqueous flavor, was included. Six of 9 judges chose it as having the strongest or best grape flavor while two chose the juice with locked flavor. From these and other comments of the judges it was concluded that the locked flavor improved the flavor of reconstituted grape juice powder, giving the juice a more pleasing and natural aroma, but there is room for further improvement. The same conclusions were drawn from organoleptic data on grape flavor locked in sorbitol (Table 2, test 8, and other data not tabulated).

DISCUSSION

The experiments reported in this paper have demonstrated the feasibility of recovering, concentrating, and locking Concord grape flavor. The locked product has been shown to give a natural flavor and aroma to reconstituted grape juice powder. However, it appears likely that efficiency of the process can be improved. The best process would give high recovery, in every step, of the important flavoring constituents but would not employ special and expensive provisions for retaining unimportant volatile materials.

In the described experimental process there was a large percentage loss of both methyl anthranilate and low-boiling constituents, the former due to poor recovery in the first step and the latter due to poor retention in the solvent removal and locking steps. However, there is evidence that important flavoring constituents were recovered better than methyl anthranilate and retained better than the low-boiling esters. This thought was developed as follows. In the experiments on the effect of 33-fold aqueous flavor, with reconstituted grape juice concentrate as base, the added grape flavor was detected when only 2.5% of the equivalent amount was added, in which case the methyl anthranilate concentration was increased by only about 1.3%. A large difference and strong preference by the panel for the sample with added flavor was noted when one-half the equivalent amount of aqueous flavor was added (Table 2, test 2), corresponding to an increase in methyl anthranilate concentration of only about 25%. It is well known that a difference in flavor between two samples cannot normally be detected unless the concentration of flavoring substances in the stronger is at least about 30% greater than in the weaker. It is concluded, therefore, that Concord grape juice contains an important flavoring substance which was recovered in the first step better than methyl anthranilate.

Since it was concluded from the organoleptic data on the fractions from the batch distillation (Table 2, tests 4, 5, and 6) that the low boiling constituents are relatively unimportant, it is now concluded that one or more important flavoring constituents are of intermediate volatility, between ethyl acetate and methyl anthranilate. Such intermediate constituents might come through the whole process in fairly good yield.

On the other hand, in light of the chemical data it appears likely that there was some loss of every one of the volatile constituents. Losses of the important constituents would appear to be the most plausible explanation for the observed deficiency in flavor quality of the flavor concentrate (in vegetable oil) and of the locked flavor, as compared with the 33-fold aqueous flavor solution.

Further research is planned to determine whether it is important to recover more of the high boiling constituents from the original juice. A procedure for completely removing iso-pentane from the extract without appreciable loss of flavoring constituents is also under consideration.

As pointed out in the first paper of this series *(14)*, volatilization losses of flavoring constituents are substantial with use of the present locking equipment. At present we are proceeding with development of means for continuous emulsification in a closed system, which should contribute to maximum retention of the flavoring constituents.

SUMMARY

The volatile flavoring component of Concord grape juice was recovered, concentrated, and locked by an experimental procedure. The steps included (1) recovery of flavoring constituents by flash vaporization and rectification, (2) concentration by distillation with a 40-bubble-plate-type column, (3) further concentration by extraction with iso-pentane, addition of rice oil or sesame oil as an extender, and removal of the iso-pentane by distillation, and (4) locking of the non-aqueous flavor concentrate in sorbitol or a sugar mixture.

No alteration in flavor resulted from concentration of the flavoring component by distillation up to 330-fold. The locked product improved the flavor of reconstituted grape juice powder, giving the juice a more pleasing and natural aroma.

Chemical analyses showed low recovery of methyl anthranilate in the first step and low retention of total volatile esters in the last two steps. However, important unidentified flavoring constituents probably came through the process with a better yield. Additional research is planned with emphasis on reduction of losses of the flavoring constituents, with the purpose of further improvements in the quality of locked Concord grape flavor.

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Preservation of Apple Cider with Sodium Sorbate[a]

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LARGE QUANTITIES OF FRESH APPLE CIDER (unpasteurized apple juice) are prepared and sold each year in this country, especially during the fall and early winter months. Fresh cider deteriorates within a few days unless yeasts and other microorganisms are inhibited.

Several measures have been used to prolong the shelf life of fresh apple cider. Gore *(6)* found that apple cider held at 32° F. (0° C.) showed no deterioration in quality for at least 36 days. However, it is usually impractical to maintain such a low temperature during the marketing and distribution of cider. Sodium benzoate has been used extensively to preserve cider. Fellers *(3)* has reported that a concentration of 0.1% is usually required to inhibit yeast growth. At this concentration sodium benzoate imparts an undesirable flavor to cider *(2, 12)*.

Sorbic acid has been found effective in controlling mold growth on cheese *(11)* and yeast growth in pickle brines *(1, 10)*. Recently Ferguson and Powrie *(4)* reported that 0.035% sorbic acid preserved the fresh flavor of apple cider stored at 77° F. (25° C. for 4 to 10 days, and that a combination of sorbic and ascorbic acids increased the period of preservation to 14 days. In the samples treated with sorbic acid, yeast growth was controlled and spoilage was reported to be due to *Acetobacter*. However, these investigations were made on a laboratory-prepared cider with a low initial yeast count and presumably low mold and bacterial counts.

The present study was conducted to determine whether sorbate would be as effective as benzoate in preserving commercial apple cider. The results indicate that sorbate, in the form of sodium sorbate for better solubility, will control yeast and mold growth in cider, but that supplemental measures must be taken to control bacterial growth.

MATERIALS AND METHODS

Representative samplings of cider were obtained from two local processors of fresh apple cider. These plants follow good sanitation practices in handling the apples before and during processing them into cider. The cider equipment was thoroughly cleaned daily. The pressed cider was pumped immediately to storage tanks in a refrigerated room held at 40° F. (4° C.). Samples were obtained from these tanks after the cider had settled for 24 hours. In addition, a sample of cider prepared in the pilot plant of the Eastern Regional Research Laboratory was included for comparison of microbial counts.

Duplicate samples were prepared for each cider treatment tested. The bottles were thoroughly cleaned and sterilized prior to filling and capping.

Sorbic acid (average particle size about 200 microns) and sodium benzoate were added to the cider as solids. Sodium sorbate was added as a 25% solution. After adding the preservatives, the cider was immediately agitated to give proper dispersion.

"Difco" wort agar was used to determine the number of yeasts and molds in the samples, and nutrient agar to determine number of bacteria. The average number of cells found on triplicate plates incubated at 86° F. (30° C.) for 72 hours are reported in the tables. Sorbic acid was determined by the analytical method of Melnick and Luckmann *(8)*.

Taste tests were conducted in conjunction with each of the cider preservation experiments. At each sampling date, cider was evaluated for flavor by a laboratory panel of 5 to 8 judges.

RESULTS AND DISCUSSION

Apple cider prepared under commercial conditions will vary widely in the number of microorganisms per unit volume, depending upon the conditions of the fruit, the daily temperature, and the sanitary conditions of the plant *(5, 7)*. The microorganism population of the commercial ciders used in this experiment was representative of that of other ciders available in this area. Table 1 gives some typical plate counts for yeasts and molds (wort agar) and for bacteria (nutrient agar) on the two commercial samples and the pilot-plant sample. The much higher microorganism counts for the commercially prepared ciders as compared to those for the pilot-plant sample emphasize the importance of using commercial samples for preservative studies.

TABLE 1

Viable cells in commercial and pilot plant cider

Source of sample	Date sample obtained	Average daily temperature	Plate count/ml.	
			Wort	Nutrient
Plant No. 1	9-22-55	70° F.	150,000	460,000
	10-12-55	67° F.	210,000	655,000
	10-20-55	56° F.	160,000	430,000
	11- 8-55	44° F.	225,000 (30 molds)	540,000
	11-22-55	42° F.	110,000 (500 molds)	225,000
	11-29-55	23° F.	155,000	141,000
	12- 9-55	34° F.	113,000	110,000
Plant No. 2	10-30-56	59° F.	460,000	600,000
	11- 8-56	52° F.	480,000	455,000
Pilot-plant	1-24-56	24° F.	6,000	4,800

As would be expected, the samples contained less

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[c] Mention of trade name does not imply endorsement by the U. S. Department of Agriculture over similar products not mentioned.

bacteria, generally, at the lower temperatures. Temperature seemed to have no effect on the yeasts and molds.

The comparative effectiveness of sodium benzoate, sodium sorbate, and sorbic acid in protecting the cider against growth of bacteria, yeasts and molds during storage at 70°–75° F. is shown in Table 2.

TABLE 2

Comparison of chemical preservatives for apple cider stored at 70°–75° F. (20°–24° C.)

Additive	Conc. of additive (g./100 ml.)	Days of storage	Plate count/ml.	
			Wort	Nutrient
None	.....	0	113,000	110,000
	.....	7	25,000,000	69,000,000
Sodium benzoate	0.05	7	2,100	320,000
	0.10	7	1,600	3,200
	0.10	14	4,000	1,150,000
	0.10	26	4,300	4,000,000
Sodium sorbate	0.05	7	9,000	736,000
	0.10	7	600	44,000
	0.10	14	8,000,000[1]	22,600,000
	0.10	26	47,000,000[1]	60,000,000
Sorbic acid	0.05	7	3,400	710,000
	0.10[2]	....	.....	.....

[1] Bacteria
[2] Not completely soluble

With no added preservative the control spoiled in 2 days, as indicated by gas formation. After 7 days the counts on the control cider on both media had reached many millions of cells per milliliter. Usually a count of a few million indicates actual or imminent spoilage.

Table 2 indicates that while all 3 preservatives were effective at the 0.05% level in controlling yeasts and molds for 7 days, they were effective only at the 0.10% level in controlling the bacteria for this period. Many manufacturers would consider a 7-day period of preservation at this temperature to be adequate.

Since the sorbic acid did not dissolve completely in the cider at a concentration of 0.10%, no results are reported for this concentration. In all subsequent tests sodium sorbate was used because of its better solubility.

Beyond the 7-day period, the bacteria overran the samples treated with sodium sorbate, as indicated by the counts on both the wort and the nutrient agar after 14 and 26 days' storage. Sodium benzoate, on the other hand, retarded microbial growth for a longer time, due principally to its ability to control bacterial growth. Although the bacterial counts for the cider treated with sodium benzoate are rather high after 14 and 26 days, these counts are many times higher for the samples treated with sodium sorbate. Sodium benzoate, however, is not a suitable preservative for cider because of its effect on flavor.

Melnick, Luckmann and Gooding *(9)* have reported that the metabolic destruction of sorbic acid by molds in cheese is directly related to the mold population. York and Vaughn *(13)* have also reported that bacteria are capable of metabolizing sorbic acid at a pH of 6.0 or above. The present study indicates that bacteria, when encountered in high numbers, are capable of destroying sorbic acid even at the lower pH's of cider (pH 3.2 to 3.6). In one test, cider containing 0.10% added sodium sorbate was stored 26 days at 73° F. (23° C.). The bacterial count rose to 60,000,000 per ml. and the sorbate concentration fell to 0.046%. A duplicate sample of cider containing 0.100% sodium sorbate plus 0.010% sodium bisulfite showed 39,500 bacteria per ml. at the end of the storage period and analyzed 0.09% sorbate. Therefore, it is apparent that destruction of sodium sorbate occurs under conditions of uncontrolled bacterial growth.

Good bacteriological control was obtained for 14 days at 73° F. (23° C.) by a combination of 0.05% sodium sorbate and 0.010% sodium bisulfite. However, a taste panel found that this concentration of sulfite imparted an objectionable flavor to the cider, and thus it cannot be recommended for cider for beverage use. It may be useful, however, for juices intended for concentrate or other products.

Reducing the storage temperature to 50° F. (10° C.) or below permitted sodium sorbate alone to control bacterial growth, and to maintain its effectiveness against yeasts and molds. Table 3 shows that sodium sorbate effectively controls microbial growths in cider at 50° F. (10° C.) for 105 days. Also at this temperature it was possible to reduce the concentration of sodium sorbate to 0.05%. Concentrations lower than 0.05% gave erratic results in controlling microbial growths.

TABLE 3

The effect of sodium sorbate on the keeping quality of cider stored at 50° F. (10° C.)

Conc. of sodium sorbate (g./100 ml.)	Days of storage	Plate count/ml.	
		Wort	Nutrient
0	0	460,000	600,000
0	9	7,250,000	7,700,000
0	48	11,500,000	6,400,000
0.05	9	500,000	540,000
0.05	48	48,000	101,000
0.05	105	960	93,500[1]
0.10	9	270,000	322,000
0.10	48	21,000	64,000
0.10	105	900	34,100[1]

[1] Many spore-formers

At a storage temperature of 40° F. (4° C.) (Table 4) untreated cider spoiled in less than 14 days. The bacterial population in the control cider was so low that the yeasts overran the nutrient agar plates. Sodium sorbate and sodium benzoate at 0.05% concentration gave excellent control of all types of microorganisms during the 120-day storage test, although in most cases the counts were lower with sodium benzoate than with sodium sorbate.

Flavor evaluation. Taste-panel evaluation of these samples showed that even at 0.10% concentrations, sorbic acid and sodium sorbate did not impart any

TABLE 4

Comparison of sodium sorbate and sodium benzoate as preservatives for cider stored at 40° F. (4° C.)

Additive	Days of storage	Plate count/ml.	
		Wort	Nutrient
None	0	113,000	110,000
	14	13,100,000	14,100,000 (y)
	26	25,000,000	18,000,000 (y)
	120	26,000,000	19,000,000 (y)
Sodium sorbate, 0.05%	14	39,000	91,000
	26	23,000	47,000
	120	12,000	21,500
Sodium benzoate, 0.05%	14	2,000	220,000
	26	.....	.....
	120	1,400	1,600

(y) = yeast

detectable off-flavors to the cider as did the sodium benzoate.

SUMMARY

Sodium sorbate preserved commercially prepared apple cider for 7 days at 70°–75° F. (21°–24° C.) and for more than 105 days at a storage temperature of 50° (10° C.) or lower. Sodium sorbate imparts no objectionable off-flavor to apple cider as does sodium benzoate.

Sodium sorbate controlled yeasts and molds, but was not effective against bacteria at high storage temperatures. When high bacterial numbers were encountered, sodium sorbate was metabolized and reduced below its effective concentration. Measures which helped to control bacterial growth in cider, such as mild refrigeration or addition of bisulfite, greatly increased the effectiveness of sodium sorbate.

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The Program of the National Canners Association on Waste Disposal[a]

(Manuscript received July 27, 1957)

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THE STORY OF THE NATIONAL CANNERS ASSOCIATION'S PROGRAM on waste disposal begins nearly 30 years ago with the first state-level legislation and enforcement aimed at stream pollution abatement. Since that time there have been steadily expanding activities both by the state agencies to strengthen and enforce the legislation and by industry to meet the treatment demands. This does not mean to imply that there has been a continual tug-of-war between state agencies and the canning industry. Requirements for stream pollution abatement are brought about by public demand which is administered through the various state agencies. It can be said that approach of the state agencies to these problems generally has been constructive. The importance of industry to the economy is usually recognized; yet it has become necessary to impose waste tretament requirements. The canning industry has maintained a cooperative relationship with the various state agencies in attempting to supply mutually saitsfactory solutions to the problems encountered.

CANNING INDUSTRY PRODUCTION

Let us explore the problem facing the canning industry. In order to do this let us look at a few background statistics.

The canning industry comprises nearly 3,000 canning plants in 47 states, Alaska, Hawaii, the Virgin Islands, and Puerto Rico. These plants produce all of the basic canned foods—vegetables, fruits and fruit juices, milk, meat, sea foods, soups, infant foods, as well as the many specialty items such as preserves, maralades, jams, jellies, condiments, etc. Altogether some 600 canned food items are distributed to the public from production of the canning industry. The 1956 pack of canned foods was almost 700 million cases containing more than 21 billion tin and glass containers divided among these main categories: seasonal vegetables, 232 million cases or 5.6 billion containers; fruits, 92 million cases or 2.2 billion containers; juices, 102 million cases or 2.5 billion containers; specialties (including baby food), 130 million cases or 4.6 billion tainers; fish, 28 million cases or 1.5 billion containers; canned poultry and meat, 37 million cases containing 1.8 billion containers. The retail value of these products is estimated at over 4 billion dollars. In the canning industry alone production workers receive annual wages amounting to over 350 million dollars. Canners provide employment at peak seasons for about 500,000 persons, and the many related industries—suppliers, distributors, transportation companies, retail establishments—multiply that total many times. Annually, canners pay to the agricultural producers of raw products about one billion dollars.

The total retail expenditures for durable and nondurable goods during 1956 amounted to 167 billion dollars. The 4 billion dollars expended on canned foods represents 2.5 % of the total, or 1 dollar in every 40 was spent on canned foods.

WATER REQUIREMENTS AND WASTE PRODUCED

To produce 700 million cases of canned food annually the canning industry is estimated to use some 36 billion gallons of water. It is true that the total water used by the canning industry is only a small fraction of that consumed by all industry. In 1950 industry was estimated to withdraw 80 billion gallons of water per day. The 36 billion gallons used annually by the canning industry represents only about 0.1% of the total; however, for treatment purposes the organic content of this waste makes it equal to some 300 billion gallons of domestic sewage annually, or in equivalent terms, about 1% of the total industrial volume.

In terms of the organic load produced in the canning industry's waste the annual biochemical oxygen demand is estimated to be 500 million pounds.

At this point it must be stated that this half billion pounds of B. O. D. represents only the potential organic load to the nation's streams. In reality only a small portion of the total load ever enters the water courses due to existing treatment practices. Estimates of the ultimate total B. O. D. contributed to the streams are not available. Treatment requirements were initiated in most areas many years ago; and since the picture is not static, current estimates could be in considerable error. Improvement in the degree of treatment provided by the industry has been steady and is expected in the future to continue in the same direction.

WASTE SOURCES AND CHARACTERISTICS

Let us review briefly the sources and character of waste from typical canning operations. Water is used for transporting the raw product and for product transfer within the process, washing at various stages of the operation, make-up of brines, syrups, etc., cooling, and steam production. With the exception of

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that used for production of steam and the comparatively small amount of water which enters the product, the water used in a canning operation eventually finds its way into a drain as waste. All water leaving the canning plant is contaminated to some degree by organic matter. Spillage of product, brines or syrups; settleable, suspended and dissolved solids contributed from soaking, washing, trimming, grading, or fluming make up the bulk of organic contamination.

Cooling water usually is contaminated with organic matter to such a minor extent that treatment is unnecessary. Thus it is seen that the waste for disposal, with the exception of the brines, syrups, or seasonings, is actually composed of portions of the product carried in a water medium.

CHANGING CONCEPTS OF WATER SUPPLY AND WASTE TREATMENT

In addition to changing concepts during the past 3 decades concerning methods of waste treatment, other changes in methods of handling food products have resulted in water consumption variations. Twenty years ago it was commonly considered that to produce the average case of canned product, 25 gallons of water were required. During the intervening years canners have constantly attempted to improve the quality and handling of the product by means that have generally meant the use of more water. Today the average water consumption is nearer to 50 gallons per case.

Now the thinking is beginning to point in another direction. The over-all water needs in the United States are increasing at a tremendous rate. Even the popular press is now devoting considerable space to the anticipated crisis. The industrial demand by 1975 is expected to be more than double that of today. Domestic demands increase steadily, and at the present rate of population increase the result will be a much higher private water usage. It is foreseeable that there may be a serious water supply crisis in the present generation.

All industry must realize these prospects and plan accordingly. There is reason to believe that the tendency for more efficient use of water with resultant savings will be accentuated in the near future. In the canning industry it means that we must look for a return to 25 gallons of water per case and even less, while still improving the quality of the product.

As might be expected, any decrease in the unit amount of water used intensifies the waste treatment problem. B. O. D. concentrations increase although essentially the same total weight of organic load is present. Where water is not available for dilution higher B. O. D. concentrations can be considerably more difficult to treat. Therefore flexible planning is necessary to cope with future treatment requirements.

WASTE TREATMENT BACKGROUND

First, let us review the background of treatment as previously and presently practiced.

Most of the states have been active in promulgating new legislation and enforcing the applicable older as well as the newer regulations. While enforcement frequently has been slow for a number of reasons, it is only a question of time before compliance with all requirements will be complete. Further, a look into the future indicates that the public will increasingly demand more stringent state laws and legislative enforcement. The impending water crisis will make necessary extremely high degrees of waste treatment. Indeed, it is foreseen that the time will soon come when waste will be treated to a potable level.

The canning industry in general has cooperated very well with the treatment requirements, but as a group realizes that there is much more room for improvement.

Already there is almost universal use of some form of treatment. In some instances this treatment may be minimal, such as solids separation, while in others complete removal of contamination may be achieved.

WASTE TREATMENT COSTS

Much of the canning industry operates on a low profit margin. Therefore waste treatment, generally considered as a non-productive expenditure, is viewed with little enthusiasm, especially by those producers who maintain seasonal operations. Frequently those with year-round operations find it easier to justify waste treatment costs since the total gross sale of their production in comparison with seasonal operations may appear considerably different for similar treatment facilities. Proposed legislation for rapid amortization of waste treatment facilities has been before Congress in each of the last several years and is presently before the House Ways and Means Committee. According to informed sources there seems little likelihood of the passage of this legislation.

Available data for waste treatment expenditures by the canning industry are by no means complete: however, some information can be reported.

Recent estimates show that the total cost of waste treatment including capital investment and operating charges is in the vicinity of ⅔ cent per case, which represents a total annual outlay of nearly 5 million dollars. Ten to 15 years ago a waste treatment cost of 0.1 cent per case was the estimate. Although production is rising, waste treatment costs are rising at a more rapid rate. The principal reasons are those stemming from the ever-increasing degree of treatment required. Increased labor and material costs have their effect but are secondary to the increased treatment requirements. Due to the changing concepts of necessary treatment facilities the unit cost of waste treatment may be expected to follow the present trend and increase substantially within the next few years.

A striking example of waste treatment cost is revealed in the records of one canning firm. During the 14-year period, 1922-35, total capital expenditures for waste treatment amounted to $25,000. This was during the very early stages of waste treatment requirements. During the next 10 years, as enforcement was

beginning to be felt, the capital outlay was $100,000. The final 11 years to date show an expenditure of $500,000 for treatment facilities. Obviously the production rate did not increase 600-700% between the latter two periods nor did it increase 20 times from the early base period.

To anticipate future waste treatment requirements, think of a further increase of 600-700 % to a cost of 4.5 cents per case within the next few years. Add to this the fact that waste treatment, as a non-productive cost, will continue to lower the profit margin and increase the competition for the consumer's dollar. It then becomes increasingly evident that efficiency of operation will play an even more dominant part in canning operations.

Many industries find that recovery of usable or marketable materials is possible to offset at least a portion of the treatment cost. However, the recovery picture in the canning waste area has not been promising. There are only a few "successful" recovery operations on a limited number of products. By "successful" we mean that recovery of some fraction of the total waste is being conducted on a full scale basis with small regard to cost. There is little evidence that a financial profit is possible. The waste recovery field is another that should and must be explored further as treatment requirements increase in intensity.

PECULIARITIES OF CANNING WASTE

Designing a treatment plant would always be simplified if uniform conditions could be anticipated. Such is not the case in canning waste treatment. The seasonal nature of many operations has already been mentioned, and the disadvantages of designing a biological treatment plant to operate 2 or 3 months a year are obvious.

Customarily a plant handles more than one product and at times will pack several simultaneously. Since each waste has characteristics dissimilar to others, the combinations of conditions causing variation can readily be seen. A good example of the difference is seen when the B. O. D.'s of the waste from various products are compared. Asparague waste B. O. D. may be as low as 16 p.p.m. while pumpkin and squash waste B. O. D. may be as high as 11,000 p.p.m.

Other important waste characteristics affecting the design of treatment are variations in solids content, pH, volume, color, temperature, odor, and deleterious mineral content.

WASTE TREATMENT METHODS

With the variables in mind, consideration can be given to the treatment methods *(2)*. The following general classifications of treatment have been or are being used at the present time:

1. Mechanical
   a) Screening
2. Chemical Treatment
   a) Chemical Precipitation
3. Biological Treatment
   a) Filtration
   b) Aeration
   c) Impounding Lagoons
4. Land Methods of Disposal
   a) Impounding Lagoons
   b) Absorption Beds
   c) Ridge and Furrow Irrigation
   d) Spray Irrigation
5. Discharge to municipal sewer systems.

Screening. Screening is minimal treatment and is widely used. At some plants screening is the only treatment used, but in a great many instances screening is a form of pre-treatment. Only the larger floating, settleable or suspended solids are removed; therefore with many products only slight B. O. D. reductions are accomplished. In fact, canning waste analytical data refer to screened samples unless otherwise noted.

Both rotary and vibrating screens are used satisfactorily. Cloth with openings finer than 40 mesh is not commonly used except on some of the circular vibrating units.

Chemical precipitation. Chemical precipitation following the general principles of water treatment was a logical early step and was well accepted some 15 to 20 years ago. Only suspended solids can be removed; hence the B. O. D. in solution is not affected. As a result B. O. D. reduction limits of 25 % with fruit waste and 40 to 50 % with vegetable waste could be expected. In actual practice most reductions fell far below these standards. During this early period such minimum efficiency was satisfactory in many areas, however it soon became evident that primary treatment would not suffice in most instances. As a result chemical precipitation is almost extinct today and can be recommended at certain plants where a low degree of primary treatment is adequate.

Biological treatment. Biological forms of treatment were next considered. At this time biological treatment methods were common in the municipal sewage treatment field and it seemed logical to apply the principles of domestic sewage treatment to industrial wastes, such as those from the canning industry.

Early attempts at the utilization of standard or high rate trickling filters for industrial wastes met with variable degrees of success. Treatment of combined domestic and industrial wastes is now standard practice, and where the design loads are not appreciably exceeded the results are satisfactory. Treatment of canning waste by biological filtration has been a different story, however, with failure as the general rule. Several reasons for these failures are apparent. First, canning waste usually is deficient in minerals nutrients necessary to the functional organisms. Nitrogen accounts for the principal deficiency although phosphorous, potassium and a number of trace elements are also critical. Correction of these deficiencies must be made by supplements to the waste.

It may also be necessary to make pH adjustments of some wastes in order to maintain the proper environment for the organisms.

The most serious deterrent has been the fact that it is necessary to make a continuous application of waste for a period of several weeks prior to the canning season in order to develop the complex biological growth on the filter medium. Waste must also be applied continuously thereafter. It can be seen that these conditions are not always easy to provide. A year-round packer may find it possible to meet these requirements, but usually a seasonal canner cannot.

Compared with domestic waste treatment, proportionately more filter capacity is necessary for canning waste due to the much higher B. O. D. concentration. Shock loads of high B. O. D. waste have serious detrimental effects on the valuable bacterial flora inhabiting the filter medium. It has been found that certain groups of bacterial cultures acclimate themselves to limited B. O. D. ranges when radical deviations are encountered these organisms are damaged.

Finally the cost is prohibitive for seasonable operations. As a result there are very few such filtration treatment facilities used.

The other biological treatment method of primary importance involves the use of air to supply oxygen to a group of organisms which feed on the organic material in the waste. Various names are applied to this form of treatment such as activated sludge, straight aeration, etc.

Two major factors have been important in the slow acceptance of aeration in the canning industry—the high capital investment required and in many instances the elaborate degree of control necessary to maintain balanced, efficient operations.

Recent experimental work with aeration has indicated that under certain limiting circumstances the method can be applied in a simplified form to obtain a high degree of purification, provided that the cost of treatment can be justified. Aeration appears particularly promising where a canner's waste admittance to a municipal sewer system is dependent on the B. O. D. level being within the general range of normal domestic sewage. Under these circumstances the aeration would be a form of pre-treatment.

At the present time the commercial use of aeration is limited to a very few installations. It is predicted that with the increasing requirements for efficiency of treatment, aeration will be utilized further.

Land methods of disposal *(3)*. During the early years it became evident that land forms of disposal were desirable, and as a result several methods of land treatment have been used.

Lagoons first became popular, although today there is less enthusiam for their use than in earlier years. Lagooning is merely the holding of liquid waste (usually after screening) in a single open pond or reservoir or series of such containers. In reality lagooning combines biological and land methods of treatment. Organisms naturally present in the soil utilize the organic matter in the waste to satisfy their food requirements, thereby providing biological stabilization.

Advantages of lagooning are the relative economy, ease of handling the waste, and under adequate design conditions the elimination of stream pollution.

Disadvantages include the amount of land utilized, possible contamination of ground water supplies, and odor arising from gases produced in the stabilization process. In most instances the odor problem becomes the critical factor. It is then necessary to resort to odor control measures, which vitally affect the economics of treatment.

A number of materials have been used for odor control. Nothing has been found to give complete control, although with proper application some alleviation may be expected. Sodium nitrate in amounts ranging upward from 200 pounds per thousand standard cases has been used extensively. Little success has been experienced with the materials variously described as "enzymes" or "bio-catalysts". Many odor masking agents have been tried. Some of these are used today to provide a perfume type odor which pervades the existing malodor and eventually becomes predominant. Unqualified endorsement cannot be given to these materials due to mixed reactions of these evaluating the results.

Other land forms of disposal were tried in the lagoon era. These included absorption beds and ridge and furrow irrigation.

Absorption beds have had very limited application due to the exacting conditions necessary for success. Wastes are flooded under controlled conditions onto shallow beds or flat land areas and allowed to percolate into the soil. A primary factor for successful odor free operation is the maintenance of rapid percolation. The waste must be free from soil-clogging particles. The ground must be level to obtain even application when flooding. Sufficient area must be available to allow a system of rotation for drying. Ground water contamination is also a factor.

Ridge and furrow irrigation requires conditions similar to absorption beds except that level land is not necessary. The system consists of a series of furrows fed by one or more header ditches, all of which follow the existing ground contours for gravity flow. Controlled waste application is made to the furrows to allow filling and absorption and adequate rest periods. Advantages and disadvantages are similar to the absorption bed method. There are only a few ridge and furrow irrigation systems in use today for total plant waste, although in recent years extensive use of this method has been made in disposing of pea vine ensilage juice.

About 10 years ago the disadvantages of the treatment methods then in use led to the adaptation for waste disposal purposes of the long established overhead sprinkler irrigation as used for agricultural purposes. Since that time the trend has been toward conversion to spray irrigation, until at the present time in some areas more than half the canners use this system.

What are the reasons for these changes? Inade-

quate degrees of treatment due to increasing requirements, odor problems, the ever-present stream pollution problem, the prospect of large expenditures for questionable biological treatment methods, and the relative simplicity of operation are factors influencing the changing trend.

Spray irrigation *(1, 4)* if properly designed and operated satisfies the requirements of present-day treatment methods. Complete treatment is provided; odor problems are completely eliminated or minimized; stream pollution is eliminated if run-off does not occur; the costs when compared to complete treatment are reasonable; and no highly trained personnel are required to control the operation.

Basically, spray irrigation consists of using plant waste as a substitute for an agricultural irrigation water supply. The fundamental difference is that in agriculture irrigation a minimum amount of water is spread on a maximum land area while in waste irrigation the reverse is true. The engineering principles of application are the same, however.

There are numerous specific requirements and limitations affecting the operation of a spray irrigation system. Winter operation in the northern areas is not possible. Those who do winter canning usually employ combined lagoon-spray irrigation systems. Winter wastes are stored until weather conditions permit spraying.

A sufficient land must be available to suit the requirements. With a known waste flow and average rainfall records it is possible to conduct a soil survey for basic data to design the necessary area. Substantial variations are found due to different soil types, ground water conditions and climatic factors; therefore, it is not practical to use any one set of data for average conditions.

A vegetative cover drop is necessary for several important reasons. Without an adequate cover the water droplets fracture the bare soil particles to produce fines which effectively seal the surface and encourage erosion. A cover crop supplies countless flexible openings in the soil by the root system. The growing plant and its moisture utilization by the evapo-transpiration phenomenon is responsible for considerable water loss to the atmosphere. A reasonable figure for the amount of water transferred from the soil system during the growing season by evapo-transpiration is 8,000 gallons per acre per day. If a 6-day rest period were provided between applications, evapo-transpiration would account for 48,000 gallons of water per acre per day or nearly 2 inches transferred to the atmosphere during one spraying cycle. Bare soil is responsible for only a small fraction of this amount.

Many crops have been used as covers. Some of these include alfalfa, clover, the tall grasses, the low or dense grasses, grain crops, and wooded land. The latter has allowed very high application rates although certain tree species have been susceptible to damage from excessive water and also from bark scoring by the water streams. Of the open land covers the best all purpose crops have been the low or dense grasses such as the fescues and blue grasses.

The use of peas, corn, or other canning crops for cover has not been extensive. Among the situations where these crops have been used the tendency has been to overwater and damage the plants. As a result moisture limits should be more carefully controlled with crops of this type.

Canning waste treated by spray irrigation is usually screened to prevent pumping and nozzle clogging problems. The common rotary or vibrating screen is satisfactory. However there has been some recent work aimed at including all the solid waste with the liquid. To accomplish this it is necessary to comminute the solids and reintroduce them into the liquid waste. Possibilities of eliminating the costly solids separation and disposal operation as well as the added fertilizing potential to the soil are incentives for such a practice. There are at the present time mechanical problems remaining, and further studies are necessary to evaluate the system.

Standard pumping facilities are used, the specific types depending on the individual requirements. These include electric, gasoline, diesel or liquid propane as sources of power. Frequently it is necessary to pump to the spray site with one operation and pump through the irrigation system with another.

Irrigation fields seldom adjoin the plant and many times are more than a mile distant. Common types of pipe are used—uncoated steel, galvanized steel, aluminum, wood, asbestos-cement, concrete, clay, cast iron, or plastic. The economics and material resistance to the waste characteristics govern the selection of the pipe. Uusually the laterals which are moved at regular intervals are of a convient light material such as aluminum.

Where the waste is moved from the plant to a sump in the field, the sump generally is designed to hold only 30 to 45 minutes of plant flow. In this way odor problems are minimized.

A uniform coverage of the spray area is accomplished by designing each lateral to be moved at frequent intervals to allow a rest period before returning to the original site. Six days is considered to be a reasonable spray interval.

Spray nozzles are self-actuated, revolving sprinklers of various sizes. The best size depends on the local conditions. The very large sprinklers are adaptable to wooded areas while the smaller sizes are best suited to open fields. However nozzle openings less than ¼ inch are not recommended due to clogging nuisance.

It may also be said that spray irrigation is not without its problems. Ground water contamination is a persistent consideration. Either inadequate area or poor management is often responsible for ponding and run-off. Land costs are frequently too high to be attractive. Distance to suitable and available sites is often a factor. Recently it has also been noted in a few instances that odor controlling procedures have been necessary due to objectionable odors even from fresh waste.

Discharge to municipal sewer systems. This brings us to the practice of disposal of canning waste directly to municipal sewage treatment plants. Where possible and permissible this method is by far the simplest and eventually the most economical. Unfortunately, the majority of canning plants are located in or near communities which do not have adequate facilities to handle the additional load created by canning waste.

For handling by a municipal system there usually is a charge assessed. The present sewer fee trend for industrial waste is on the basis of (1) volume, (2) pounds of B. O. D. in excess of that normal to domestic sewage, and (3) suspended solids in excess of that normal to domestic sewage. Any one or combinations of these factors may be used as the basis for charges.

FUTURE CONSIDERATIONS

Where do we go from here? We have already observed that the future will see greatly increased requirements for all industrial waste treatment. We have also noted that in the foreseeable future the water supply crisis throughout the nation will force waste treatment to the potable water level. It is then logical to predict that industry as well as communities will be faced with fantastic costs to obtain such treatment levels. Indeed, we can foresee water shortages and competition for the supply to the degree that regulated controls will be necessary.

How can industry meet this challenge? First, there must be concentrated efforts aimed at water economy and increased efficiency of water usage. Work of this nature is presently underway in the West, but only on a small scale. A great amount of research is necessary to anticipate and meet the critical problem before it is too late.

Second, there must be widely expanded work to develop new and improve existing waste treatment methods to obtain the efficiencies that eventually will be required. The only way to do this is by expanded research activities. More investigators must be attracted to the waste treatment field. More funds must be made available for this purpose. More interest must be shown by top management.

Further, the cooperative approach to these problems is necessary. All the agencies concerned with the water and waste problem must join in looking for solutions to the problems common to industry and municipalities. Those in the various industries, the research organizations, the conservation groups, the municipal officials, the state regulatory authorities, and the Federal Government should develop closer working relationships to get the most good from the available facilities.

In this connection we can report that a small start in the cooperative direction has already been made. A very minor amount of Federal funds is currently being used for waste disposal research studies at the University level. Additionl funds for industry use may soon be available, but these are only the smallest start at what will be necessary to meet the difficult and complex waste disposal problems facing the canning industry.

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Trihydroxybutyrophenone—A Food Grade Antioxidant

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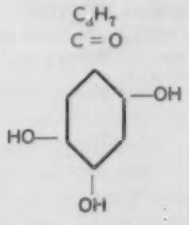
(Manuscript received May 14, 1957)

THE SEARCH FOR IMPROVED METHODS of stabilizing unsaturated compounds against breakdown due to autoxidation is a continuing challenge for those who manufacture antioxidants. Knowles *et al. (4)* have reported on the comparative antioxidant potency of the 2,4,5-trihydroxyphenones and have shown that the lower members of the series are effective in lard, paraffin wax, mineral oil, and peanut oil. They also report a very low order of toxicity for the 2,4,5-trihydroxyacetophenone and 2,4,5-trihydroxybutyrophenone. Lehman *(5)* has recently included 2,4,5-trihydroxybutyrophenone (THBP) in a listing of antioxidants established as safe for use in edible fats and oils and plastic food wraps.

This paper describes the physical and chemical properties of 2,4,5-trihydroxybutyrophenone and shows the magnitude of stability increase which can be produced in some fats and oils, cereals, vitamin A, and paraffin wax. Figure 1 shows the chemical structure of this substituted phenol and some of the more important physical properties.

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1957.

Chemical Structure



Molecular weight.....196
Physical state.....Tan powder
Melting point, ° C.....149-153° C.
Solubility.....See below

Solvent	Temperature °C.	Approximate Percent Solubility
Water	50	0.5
Ethanol	20	30
Propylene glycol	20	30
Corn oil	20	1.5
Cottonseed oil	20	1.5
Mineral oil	20	2.5
Lard	50	2.5
Oleo oil	50	2.5
Benzene	30	0.2

Remarks: Produces light tan to brown color in the presence of organic metal salts. Citric acid and other chelating agents will partially inhibit formation of this color.

Figure 1. Some properties of 2, 4, 5-trihydroxybutyrophenone

EXPERIMENTAL

Trihydroxybutyrophenone was compared with butylated hydoxyanisole, butylated hydroxytoluene, and propyl gallate in lard and cottonsed oil at varying concentrations to determine its effectiveness in edible animal fats. All samples of fat were stabilized by heating to 140° F. and adding the required amount of antioxidant as a solution in ethanol.

The mixture was continually agitated for ½ hour at 140° F. (60° C.) and then allowed to cool. Portions of this stabilized fat, along with a control, were tested by the Active Oxygen Method *(6)* to determine the comparative effectiveness of the antioxidants in producing initial stability against oxidative breakdown. The Active Oxygen Method (or Swift Stability Test) was run in this experiment by the technique described in the above reference. A sample of fat was held at a constant 210° F. (98.5° C.) and air passed through it at a specified rate. A 0.2 g. sample of the test fat was removed periodically and analyzed for peroxide content using a starch-iodine-sodium thiosulfate reaction. A peroxide value of 20 meq. for the animal fat and 70 meq. for the vegetable oil was used as the end point. All data are quoted as average hours to reach these end points under the above conditions. Samples of fat, stabilized by the above method, were also evaluated for carry-through stability by the Schaal Oven Method *(3)*. In this particular test, a fat was used to prepare potato chips and crackers under standard laboratory conditions. These foods were placed in storage at 145° F. (63° C.) and smelled daily by a trained organoleptic panel. When a majority of the panel agreed on the rancidity of a sample by odor, it was removed from the test. The data were reported as the average days stable under the above conditions.

Both the Schaal Oven Test and the Active Oxygen Method are known to have a large inherent error. A summary of this magnitude of error follows so that the uninitiated reader may better evaluate the data. The Active Oxygen Method has an error at a 95% confidence limit for the mean of triplicate tests on lard of approximately ± 16% for this particular set of conditions. For vegetable oils, the comparable 95% confidence limits are approximately ± 13%.

For crackers prepared with lard, the 95% confidence limits on the Schaal Oven Test are approximately ± 26% for the average of two bakings using 4 samples from each baking. For a single baking and 4 samples the limits rise to ± 48%. For potato chips fried in cottonseed oil, the Schaal Oven Test gives somewhat less variability than for crackers and cereals.

Figures 2, 3, 4, and 5 show the effectiveness of trihydroxybutyrophenone on edible fats. It may be seen from these graphs that trihydroxybutyrophenone is about equal or slightly better than propyl gallate in producing initial stabilities in animal fats and equal in vegetable oils. It is better than propyl gallate and butylated hydroxytoluene under deep fat frying conditions but about equal to butylated hydroxyanisole. It is not as good as butylated hydroxyanisole and butylated hydroxytoluene in producing stabilities which carry through into the finished baked foods.

Another important field for food grade antioxidants is the vitamin field. In order to test the effectiveness of trihydroxybutyrophenone, natural vitamin A in pollock liver oil was used as the test medium. Samples of the oil concentrate were stabilized by adding the desired concentration of antioxidant in an ethanol solution. The fish oil was then diluted with petroleum ether to a standard quantity and portions of the diluted oil were pipetted into a 50-ml. beaker containing one layer of 4-mm. glass beads as described by Spruyt *(8)*. The beakers were allowed to stand in the dark overnight for the petroleum

ether to evaporate. The vitamin A activity was determined by the Carr Price Method *(1, 2)* using one beaker for each sample. The remaining beakers from each lot were stored in an oven at 100° F. (37.5° C.). Analyses for vitamin A activity were made periodically until a loss of 50% activity occurred. Although this vitamin A test method has not been analyzed statistically under these conditions, it is a type of Schaal Oven

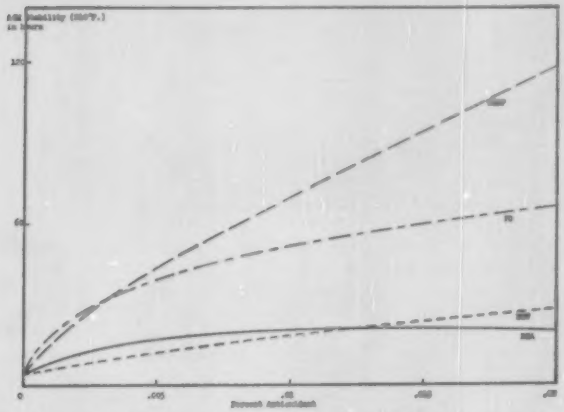


Figure 2. Stabilization of lard (As judged by the Active Oxygen Method).

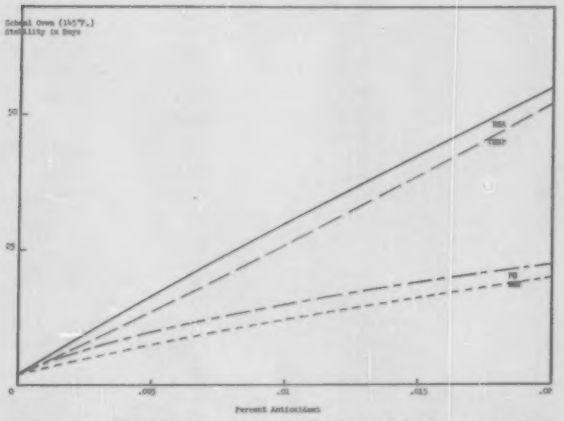


Figure 3. Stabilization of lard (As judged by testing potato chips by the Schaal Oven Method).

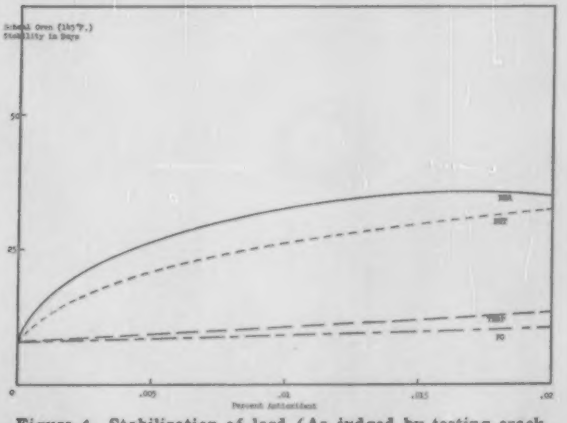


Figure 4. Stabilization of lard (As judged by testing crackers by the Schaal Oven Method).

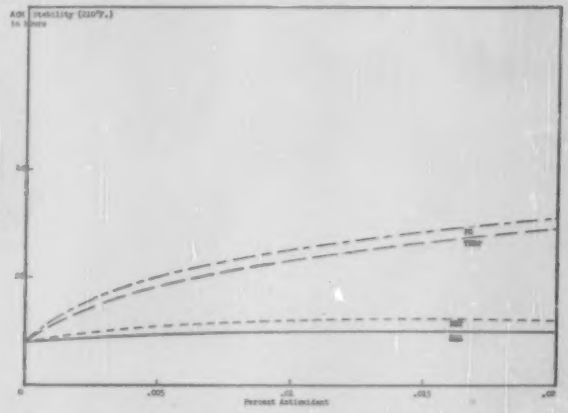


Figure 5. Stabilization of cottonseed oil (As judged by the Active Oxygen Method).

Test and our experience with it indicates an order of reproducibility comparable with other Schaal Oven data. Results may be sen in Figure 6.

These results indicate that trihydroxybutyrophenone has excellent activity in producing stability in vitamin A. In this test it had not reached its peak in effectiveness at .50% although in other pollock oils tested previously it reached its peak effectiveness at about .30% active ingredient and higher quantities seemed to have little effect in enhancing the stability of the vitamin A.

A third field where antioxidants are becoming quite generally used is in the cereal field, particularly in certain breakfast cereals and cereals for feeds. Trihydroxybutyrophenone was tested in cereal products by spraying samples of wheat cereal, corn cereal and rice cereal with varying quantities of the antioxidant in vegetable oil. In this particular case, it was compared only with one concentration of an antioxidant mixture containing butylated hydroxyanisole and butylated hydroxytoluene in vegetable oil since this combination is widely used in the cereal field. The concentrated mixture was diluted with vegetable oil so the finished cereal would contain .005% butylated hydroxyanisole plus .005% butylated hydroxytoluene as is now being used in many commercial applications. Samples were then placed at 145° F. (63° C.) and smelled daily by an organoleptic panel. This test method has not been analyzed statistically, but its reproducibility may be expected to be typical of Schaal Oven data. Results of these tests may be seen in Figure 7.

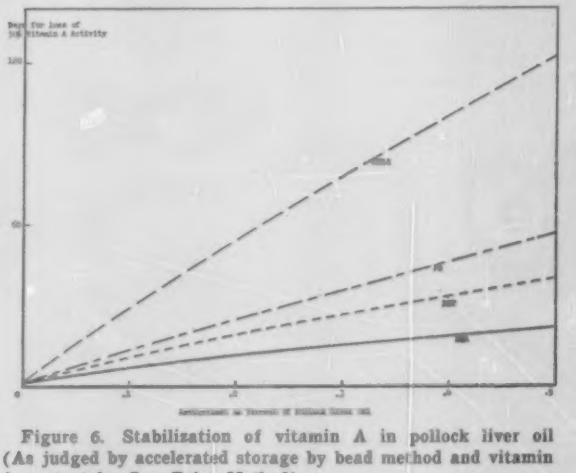


Figure 6. Stabilization of vitamin A in pollock liver oil (As judged by accelerated storage by bead method and vitamin A content by Carr-Price Method).

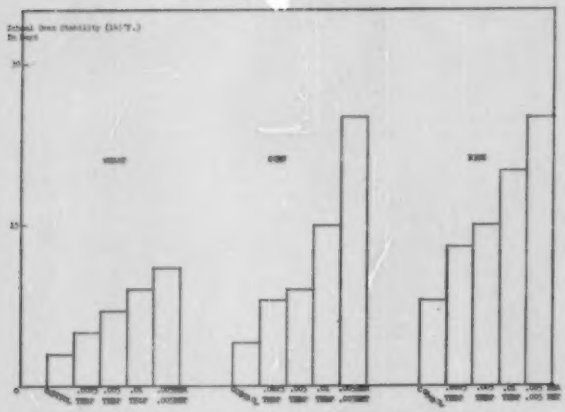


Figure 7. Stabilization of breakfast cereals (As judged by the Schaal Oven Test).

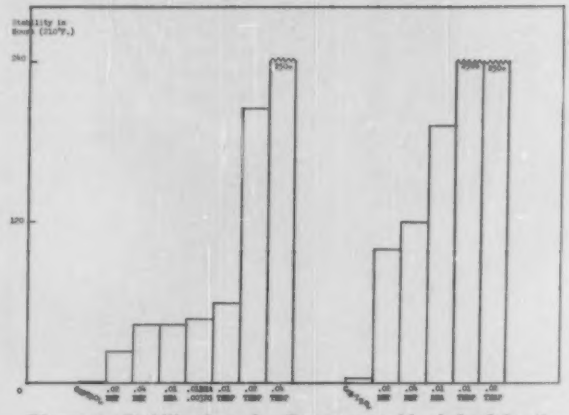


Figure 8. Stabilization of yellow grease (As judged by the Active Oxygen Method).

It may be noted from these figures that trihydroxybutyrophenone is not equal to a combination of .005% butylated hydroxyanisole plus .005% butylated hydroxytoluene which is normally considered the best combination for this use under commercial conditions.

Another field which uses large quantities of food grade antioxidants is the inedible fat field. Antioxidants are added to inedible fats such as yellow grease and brown grease which are in turn added to mixed animal and poultry feeds to enhance the caloric content. Antioxidants inhibit serious flavor changes and loss of vitamin content by stabilizing the fatty portion of the feed.

Yellow grease was stabilized by adding ethanolic solutions of antioxidants in the same manner as described for lard and vegetable oil. Since yellow greases always require chelating agents for effective stabilization because of large amounts of pro-oxidants present, citric acid was added to each sample along with the antioxidant. The concentrations of antioxidants reported do not include this chelating agent but only include the active antioxidant ingredient. In this case, trihydroxybutyrophenone was compared with butylated hydroxytoluene, butylated hydroxyanisole, and butylated hydroxyanisole plus propyl gallate which are the commercial antioxidants used by most renderers of inedible greases. Since yellow greases with different initial stabilities vary greatly in their reactions with antioxidants, samples were prepared using both a poor grease (¼ hour AOM initial stability) and a medium grease (4 hours AOM initial stability). Active Oxygen Method stabilities were run on these samples and the data may be seen in Figure 8. The 95% confidence limits for Active Oxygen Method on yellow grease were found to be similar to lard, about ± 20%.

These data show that trihydroxybutyrophenone is an excellent antioxidant for inedible fats. Much lower quantities of trihydroxybutyrophenone can be used in these particular yellow greases and still produce stabilities satisfactory for feed manufacturers.

A fifth field which must be considered for food grade antioxidants is the paraffin wax field because of the large quantities of stabilized waxes used in food packages. Trihydroxybutyrophenone was tested in paraffin wax by adding an ethanolic solution to wax being agitated at 140° F. (60° C.). Samples were evaluated at 300° F. (150° C.) by the Active Oxygen Method as described by Seubert and Andrews *(7)*. A peroxide value of 50 meq. was used as the end point in this particular study. Butylated hydroxytoluene is used almost exclusively where an edible antioxidant is necessary for preventing breakdown in paraffin waxes. Trihydroxybutyrophenone was tested against various concentrations of butylated hydroxytoluene without using either butylated hydroxyanisole or propyl gallate. The results of these evaluations may be seen in Figure 9. A statistical analysis of this test method showed the 95% confidence limits for the mean of three replicates to be approximately ± 13%.

These data indicate that trihydroxybutyrophenone is an excellent antioxidant for paraffin waxes, being approximately three times as effective in the particular wax tested as butylated hydroxytoluene. Some color formation with trihydroxybutyrophenone, particularly at high temperatures (300° F.) (150° C.) and high concentrations (.02%) was noticed. It is not believed that this color degradation would be a problem under normal conditions.

DISCUSSION

Accelerated laboratory tests indicate that 2,4,5-trihydroxybutyrophenone has excellent possibilities as a commercial food grade antioxidant in certain fields. It is apparently quite effective in those products where an extremely potent antioxidant is needed to produce satisfactory stability. 2,4,5-Trihydroxybutyrophenone was found to be much better in paaffin wax than the butylated hydroxytoluene which is the most widely used commercial product in this field. The slight discoloration at high temperatures will probably cause no difficulty under normal conditions. Vitamin A which normally reacts poorly to antioxidant treatment was stabilized quite readily by this experimental material. This fact was also true in low stability yellow grease which can usually be

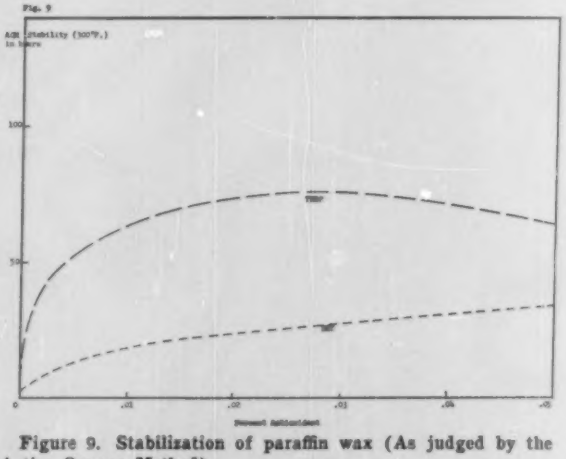


Figure 9. Stabilization of paraffin wax (As judged by the Active Oxygen Method).

stabilized only with a maximum quantity of antioxidant and chelating agents. It is believed that this antioxidant will probably find its greatest use in these and similar fields in addition to its use as an industrial antioxidant.

Trihydroxybutyrophenone does not seem to be more effective at normal concentrations than our present commercial antioxidants in edible fats such as cottonseed oil, lard, and some cereal oils. Shelf tests are now being conducted on this antioxidant to determine its effectiveness under normal storage conditions. It is not believed that these shelf tests will change the relative effectiveness of the antioxidants reported in this paper.

SUMMARY

2,4,5-Trihydroxybutyrophenone, a food grade antioxidant, was compared with butylated hydroxyanisole, butylated hydroxytoluene, and propyl gallate. In edible fats, it was shown to produce initial stability equal to propyl gallate but had little or no carry-through properties in baked goods. It was found to be extremely active in vitamin A, yellow grease and paraffin wax.

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The Influence of Sugar in Ice Cream

I. Consumer Preferences for Vanilla Ice Cream

(Manuscript received July 11, 1957)

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Sugar is an essential ingredient of ice cream affecting palatability, body and texture, freezing point, and storage properties. At present, approximately 15% sugar, or the comparable sweetness equivalent, is accepted by the ice cream industry as being the most desirable level. Although laboratory studies on sugar levels in ice cream have been reported in the early literature, little has been done on the relationship of sweetness with consumer acceptance as determined by modern taste testing techniques.

In 1923, Williams *(13)* reported that of 443 people tested, 90% preferred ice cream containing 16% or more sugar. Reid *(9)* tested ice cream containing 8, 12 and 16% sugar in 1924, and concluded that 12% was optimum since 16% sugar was too sweet. In 1936, Lucas, Matsui, and Mook *(6)* evaluated ice cream containing 11, 13, 15, 17 and 19% sugar and found the 15% and 17% sugar packs were highest in body and texture. These workers further stated: "Inasmuch as those (ice creams) containing 17% sugar were considered slightly too sweet, it is believed that the optimum sugar content for ice cream lies between 13 and 15%."

The present study concerns the determination of the optimum sweetness level in vanilla ice cream by a mass consumer panel. Effect of sugar on the physical characteristics of the ice cream will be covered in a subsequent paper.

METHODS AND MATERIALS

Ice cream samples. The ice cream used in this study was prepared by the University Creamery under standard commercial conditions. The pack contained 12% butterfat, 11% serum solids, 0.3% stabilizer, 1½ ounces of vanilla flavoring per gallon of mix, and a small amount of yellow coloring. Sucrose levels of 11, 13, 15, 17 or 19% were added to the batch. The mix was pasteurized at 160° F. for 30 minutes, homogenized, and cooled. Samples were packed in 4-ounce cups, hardened at −10° F., then stored at −10° F. for approximately 3 weeks.

Preliminary studies. Butterfat content and type of sweetener used were selected on the basis of the inability of a trained laboratory taste panel to distinguish, by triangle test procedure, between samples containing the following:

1. 15% sucrose vs. 12% sucrose plus 4% corn sweetener.[a]
2. 12% butterfat vs. 15% butterfat.[b]

After selection of the final samples, sweetness preferences were obtained by the method of paired comparison from a laboratory panel of 22 trained tasters as well as from a group of

[a] Thirty correct separations from a total of 78 evaluations.
[b] Thirty-four correct separations from a total of 81 evaluations.

69 businessmen who were convening on campus. The former panel evaluated the ice cream on 6 consecutive afternoons whereas the latter group had single-occasion tasting after their evening meal. Neither group was aware of the fact that the samples differed only in sugar level.

State fair consumer survey. The California State Fair, held in Sacramento from August 29 through September 9, 1956, was the setting for the mass consumer evaluation of the 5 ice cream samples. Several investigators have used the Fair population to determine sweetness preferences in wines and in canned cling peaches with good reproducibility of results from year to year *(1, 4, 5, 10, 11)*.

The ice cream tasting booth, located in the Food and Hobbies Building on the Fairgrounds, consisted of 6 individual windows through which samples were served. The tasting was open to the general public from 12 a.m. to 8 p.m. Children under 12 were allowed if accompanied by an adult. Each consumer was greeted by a receptionist who recorded his sex, age group, height and weight, and frequency of consumption of ice cream. A measuring tape and scales were available for checking heights and weights. After this information was obtained, the consumer took his score card to a window where he received two 2-ounce samples of ice cream marked "1" and "2" and was asked to check his preference. The color of the score card designated the combination of samples received. Care was taken to present the 10 possible combinations of pairs an equal number of times, insofar as possible. For each combination, the order of presentation was reversed in one-half of the cases to compensate for any first-sample bias.

Statistical analysis. To facilitate statistical analysis, the percent preferences for each sample within each of the possible paired combinations, were converted into a form in which they would be independent of the variances. This transformation was effected by applying the conversion formula

$$\times = \text{arc sin } \sqrt{\text{percentage}} \qquad (3)$$

The ice cream preference data were treated as a balanced incomplete block and analysis of variance was performed on the values of X, disregarding the fact that the × values represent angles. For testing the differences between means, the method described by Cochran and Cox was used *(2)*.

RESULTS AND DISCUSSION

Preliminary studies. Comparative sweetness preferences expressed by the laboratory panel and by the group of 69 businessmen are presented in Table 1. The laboratory panel showed a decided, though not significant, preference for the least sweet sample whereas the reverse was true for the businessmen. The latter group commented that the sweeter samples were "richer" and "more flavorful." Previous studies have shown that trained tasters preferred less sweet samples than did consumers *(8, 10)*.

State Fair consumer survey. Over 6,000[c] State Fair Consumer evaluations were collected during an 11-day period. Table 2 shows the tested population classified by age and sex. The largest group is composed of children under 16 years of age, an age group that probably consumes the greatest amount of ice cream in this country. Slightly more females than males participated.

[c] Different totals appear throughout the paper because of incorporation of all score cards despite incompleted answers on age, sex, height and weight, or frequency of use.

TABLE 1

Comparative preferences for vanilla ice cream (preliminary study)

Type of Panel	Total No. Eval.	Sugar Level				
		11%	13%	15%	17%	19%
		Percent Preference				
Laboratory	132	29.8	20.0	23.7	17.5	....[1]
Business Men	69	5.8	23.3	21.7	24.6	24.6

[1] Not evaluated.

TABLE 2

Age and sex classification of consumers surveyed

Age	Male	Female	Totals
Under 16	1399	1051	2450
16 - 25	341	382	723
25 - 50	903	1265	2168
Over 50	308	482	790
Totals	2951	3180	6131

Effect of environmental temperature. To determine whether the very sweet samples would be preferred more often on cooler days than on very warm days, the data were separated according to the maximum daily temperature (Table 3). Although the percent preference for each ice cream sample varied from day to day, the responses did not seem to be influenced by environmental temperature in the range observed. The 11 groups were in complete agreement from day to day that the 11% sugar sample was the least liked. The total preference shows that the three highest sugar levels were preferred over the 11 and 13% levels. A slight bias for the first sample within each pair was noted in this study and has been reported in previous similar surveys *(1, 10, 11)*.

Effect of age and sex. Analysis of the data classified by sex and age is presented in Table 4. There was a significant difference in comparative preferences as a result of treatment except for females under 16. Males exhibited a greater difference between treatments than did females. For the oldest and youngest age groups, there were significant differences only between the lowest and the three highest sugar levels. The two middle age groups, however, agreed as a group and showed decided preferences, distinguishing between the 11 and 13% sugar levels as well as between the three highest and two lowest levels. Ice cream samples containing 15, 17 and 19% sugar were equally liked but were preferred to a significant degree over the 11 and 13% levels. A graphic presentation of the total comparative preferences is given in Figure 1.

Effect of frequency of consumption. When the data were classified by frequency of consumption, it was

TABLE 3

Environmental temperature and comparative preferences for sweetness levels in vanilla ice cream

Maximum Daily Temperature	Sucrose Levels					Number Participants
	11%	13%	15%	17%	19%	
°F.	Percent Preference					
79	16.6	20.3	23.2	16.4	23.5	664
79	14.2	17.3	25.2	22.3	21.0	632
81	14.1	16.5	23.4	25.8	20.3	419
82	16.0	17.4	22.6	23.1	20.9	707
85	16.1	21.4	19.2	22.5	20.8	635
86	12.6	13.1	31.6	22.6	20.1	557
87	11.6	17.7	19.4	25.9	25.4	671
93	13.3	25.6	27.4	14.1	19.5	645
93	13.9	25.9	19.5	25.9	14.8	410
97	15.4	20.4	16.9	21.8	25.5	545
98	9.9	33.9	0[1]	28.1	28.1	292
Total Preference	14.4	20.0	22.4	22.2	21.0	6,177

[1] Not evaluated.

TABLE 4

Analysis of sweetness preferences in vanilla ice cream classified by sex and age

Age and Sex Classification	Sugar Levels					F Ratio	L.S.D.
	11%	13%	15%	17%	19%		
	Values of Arc Sin $\sqrt{p}$						
Males							
Under 16	39.5	43.2	47.4	48.5	47.9	6.78**	4.4
16 - 25	31.1	43.9	48.2	50.1	52.2	4.56*	11.8
25 - 50	35.5	44.4	48.0	49.0	48.2	4.49*	8.0
Over 50	36.8	39.3	51.8	45.4	51.7	4.65*	9.6
Totals	35.7	42.7	48.8	48.2	50.0	22.79***	3.7
Females							
Under 16	39.4	44.7	48.2	47.7	45.0	2.87	....
16 - 25	35.2	44.3	54.8	44.2	46.5	5.29**	9.1
25 - 50	38.9	44.5	49.2	46.3	46.1	8.08**	4.0
Over 50	37.4	41.7	49.5	49.2	47.2	3.95*	8.1
Totals	37.7	44.6	50.4	46.9	46.2	5.31**	9.1
Total Population							
Under 16	38.7	43.9	47.5	48.0	46.7	4.05*	5.8
16 - 25	33.3	44.5	51.4	41.9	48.9	5.35**	9.1
25 - 50	37.5	44.4	48.8	47.4	46.9	5.34**	5.9
Over 50	38.0	40.7	49.6	47.8	49.0	3.51*	7.7
Grand Total	36.9	43.4	46.8	46.3	47.9	22.12***	3.1

* Significant at P = 0.05
** Significant at P = 0.01
*** Significant at P = 0.001

found that 4,933 individuals consumed ice cream several times a week, 1,084 people ate ice cream several times a month, and only 99 consumers ate the product several times a year or never. Since these 99 responses were distributed among the 20 possible paired combinations, the numbers were too small to be analyzed individually. Consequently, only the first two categories were analyzed. Analyses of the comparative preferences classified by sex, age and frequency of consumption are given in Tables 5 and 6. In general, greater preferences for the three sweetest samples were obtained from the more frequent users. Males showed more decided preferences as a group than did females and the females seemed to be more influenced by frequency of consumption than did males. In general, more frequent users of ice cream showed a definite, although not significant, preference for 15% sucrose. Those in the age groups 16-25 and over 50 were most affected by frequency of consumption.

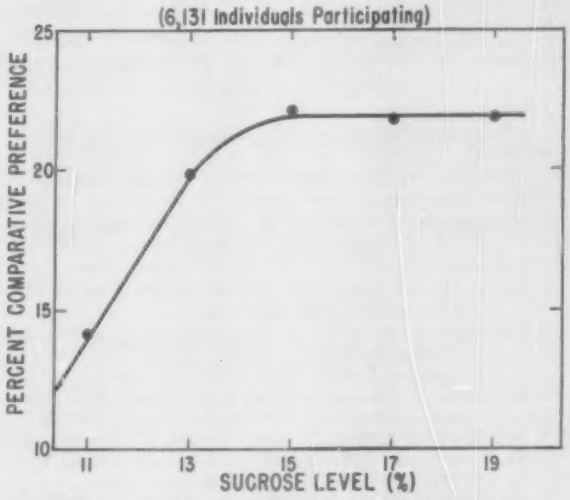

Figure 1. Sweetness preference in vanilla ice cream.

Effect of body size. Heights and weights collected were compared against standard tables of "ideal" weights *(7)*. From a total of 6,093 consumers, 21.5% were underweight, 44.8% were of normal weight, and 33.7% were overweight. The data in Table 7 shows there was little influence of body size on sweetness preference. There was a slight, though not significant, tendency for overweight individuals to show a higher preference for ice cream with 17% sugar than did the other two groups. These observations are in line with previous findings *(8, 12)*.

TABLE 5

Analysis of sweetness preferences classified by sex and frequency of consumption

Sex and Frequency of Consumption	Number	Sugar Levels					F Ratio	L.S.D.[1]
		11%	13%	15%	17%	19%		
		Values of Arc Sin $\sqrt{p}$						
Male								
Several times/week	2419	36.4	43.3	48.5	47.8	48.6	5.07**	7.0
Several times/month	468	37.1	44.7	45.0	48.2	49.8	4.55*	6.9
Female								
Several times/week	2514	38.1	42.6	50.4	47.6	46.3	5.48**	6.2
Several times/month	616	40.7	48.4	46.7	44.1	45.1	2.55	....
Total								
Several times/week	4933	37.2	42.9	49.5	47.9	47.5	5.70**	6.3
Several times/month	1084	39.1	47.0	46.1	43.8	47.1	2.09	....

[1] Least significant difference between average values at the 5% level of probability.
* Significant at P = 0.05.
** Significant at P = 0.01.

TABLE 6

Analysis of sweetness preferences classified by age and frequency of consumption

Age and Frequency of Consumption	Number	Sugar Levels					F Ratio	L.S.D.[1]
		11%	13%	15%	17%	19%		
		Values of Arc Sin $\sqrt{p}$						
Under 16								
Several times/week	2061	36.2	43.3	48.2	48.3	47.0	5.37**	6.6
Several times/month	348	40.5	47.9	47.1	46.0	46.0	1.31	....
16 - 25								
Several times/week	539	32.2	43.7	51.7	48.4	48.9	5.18**	10.2
Several times/month	165	38.4	48.9	48.3	41.4	48.0	13.65***	5.2
25 - 50								
Several times/week	1691	37.2	43.5	49.4	48.0	47.0	5.04**	8.2
Several times/month	440	38.9	45.9	47.0	47.1	46.2	2.12	....
Over 50								
Several times/week	642	38.4	39.4	50.9	47.6	50.1	4.45*	8.5
Several times/month	131	35.6	51.4	44.9	47.0	46.1	14.62***	4.6
Total								
Several times/week	4933	37.2	42.8	49.3	48.2	47.5	5.75**	6.3
Several times/month	1084	39.1	47.0	46.1	45.7	47.1	3.73*	5.2

[1] Least significant difference between average values at the 5% level of probability.
* Significant at $P = 0.05$.
** Significant at $P = 0.01$.
*** Significant at $P = 0.001$.

TABLE 7

Analysis of sweetness preferences classified sex and body size

Sex and Body Size	Number	Sugar Levels					F Ratio	L.S.D.[1]
		11%	13%	15%	17%	19%		
		Values of Arc Sin $\sqrt{p}$						
Males								
Underweight	657	37.0	43.9	47.7	49.2	47.3	4.39*	7.0
Normal	1177	35.0	44.4	47.6	48.7	49.3	4.52*	8.3
Overweight	1073	36.6	39.8	50.0	48.6	49.9	4.90*	8.6
Females								
Underweight	656	38.9	44.2	48.5	47.0	46.3	2.13	....
Normal	1554	38.6	44.6	49.4	46.2	46.2	3.98*	6.0
Overweight	976	38.9	42.1	50.1	48.7	45.2	2.67	....
Total								
Underweight	1313	38.0	44.4	48.2	47.6	46.8	3.70*	6.5
Normal	2731	37.2	44.4	48.8	48.6	45.9	6.10**	5.7
Overweight	2049	37.7	41.1	49.9	48.6	47.8	4.45*	7.6

[1] Least significant difference between average values at the 5% level of probability.
* Significant at $P = 0.05$.
** Significant at $P = 0.01$.

SUMMARY

Over 6,000 consumers evaluated vanilla ice cream containing 11, 13, 15, 17, or 19% sugar, by the method of paired comparison-preference. The results showed that the three higher levels were liked equally well but were preferred to a significant degree over the 11 and 13% sugar levels. Neither environmental temperature nor body size seemed to influence sweetness preferences. Males showed more decided preferences as a group than did females and the two age groups of 16 to 25 and 25 to 50 showed more discrimination than younger or older consumers. People who consumed ice cream several times a week had more decided preferences than did those who ate the food less frequently. By all methods of classification of the data, the sample containing 11% sucrose was the least often preferred.

ACKNOWLEDGMENTS

Appreciation is extended to members of the Department of Food Technology who assisted in conducting the survey. The authors are grateful to Mr. F. Filipello and to Dr. H. L. Alder for their suggestions on the methods of analysis. Funds for the support of this research were provided through contract with the Sugar Research Foundation, Inc., New York.

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Glucose Oxidase in the Protection of Foods and Beverages[a]

(Manuscript received May 13, 1957)

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GLUCOSE OXIDASE-CATALASE ENZYME SYSTEM catalyzes the oxidation of glucose by molecular oxygen. A simplified equation of this reaction is:

$$C_6H_{12}O_6 + O_2 + H_2O \xrightarrow[\text{oxidase}]{\text{glucose}} C_6H_{12}O_7 + H_2O_2$$

$$2H_2O_2 \xrightarrow{\text{catalase}} 2H_2O + O_2$$

Net reaction

$$2C_6H_{12}O_6 + O_2 \xrightarrow[\text{system}]{\text{enzyme}} 2C_6H_{12}O_7$$

Thus, this enzyme system offers two types of protection for foods. Foods subject to deterioration because of the presence of glucose are protected by the enzymatic oxidation of glucose prior to packaging. In cases where oxygen is the causative agent of deterioration, glucose oxidase offers protection by catalyzing the reaction of oxygen with glucose. In contrast with chemical antioxidants, glucose oxidase offers continuing protection as it is not oxidized itself. The characterization of glucose oxidase[b] and examples of its use are presented in this paper.

ENZYME CHARACTERISTICS

Thermal stability. Of direct bearing on how and when this enzyme may be used in a processing line is its thermal stability. Data presented in Table 1 were obtained by placing a known amount of enzyme in a 3.3% glucose solution at pH 4.5 and determining glucose oxidase and catalase potency after holding the solutions at the indicated temperatures for 3, 6, and 9 minutes. Glucose oxidase activity is relatively long lived at 150° F. and 170° F. Catalase activity was even more stable at these temperatures and was able to withstand a temperature of 190° F. for short periods.

TABLE 1

Thermal stability of DeeO at pH 4.5 and in the presence of 3.3% glucose

Time, min.	130° F.	150° F.	170° F.	190° F.
	Glucose oxidase activity remaining, %			
3	96	77	89	83
6	94	77	77	0
9	94	77	63	0
	Catalase activity remaining, %			
3	100	100	96	89
6	100	100	100	63
9	100	100	97	42

pH optima. Determinations of pH optima were made in systems containing 0.133M glucose and acetate buffers. The enzyme concentration was low enough so that lack of substrate would not be a limiting factor. Glucose oxidation was calculated from the determined amounts of gluconic acid formed in 30 minutes at 30° C. and 35° C. In Figure 1, it can be seen that the optimum pH is to a certain extent dependent on temperature. At 30° C., there is a broad plateau of activity from pH 3.0 to pH 7.0 with greatest activity at pH 5.5. There is this same general plateau at 35° C. except that above pH 6.0 there is a rapid drop in enzyme activity. At both temperatures, the enzyme was inactive at pH 2.0.

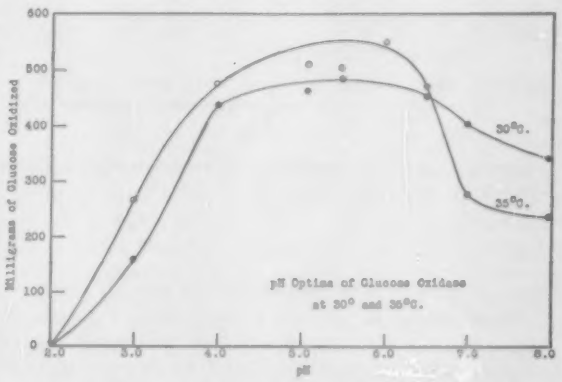

Figure 1. pH optima of glucose oxidase at 30° C. and 35° C.

Rate of glucose oxidation. The procedure used for determining the rate of glucose oxidation was essentially the same as that used for the pH optima study. A pH of 5.5 was used at both 30° C. and 35° C. Aliquots of the solution were taken at the intervals indicated in Figure 2. At 30° C. glucose oxidation is linear with time but at 35° C., the rate of oxidation starts to decrease after about 40 minutes reaction time. After 60 minutes more glucose was oxidized at 30° C. than at 35° C. despite the greater initial oxidation rate at the higher temperature. The decrease in oxidation rate at the higher temperature was probably due to faster enzyme inhibition by the gluconic acid formed. This is in accordance with the findings of Muller (3) in his early work on glucose oxidase.

Oxygen uptake. Using a mixture of glucose oxidase-catalase enzyme, glucose and extender, the rate of oxygen uptake was determined. This mixture, placed in one-ounce paper cups, was sealed into No. 2 cans. At various intervals, the oxygen content of the cans was measured with an Orsat gas analysis apparatus. Mixtures of 400 units of glucose oxidase activity, 0.0065 and 0.008 moles of glucose in the presence of about 65% moisture at 30° C. were arbitrarily used in these tests. As can be seen in Figure 3, oxygen utilization was linear with time for the first 24 hours. After this, the rate of oxygen utilization decreased. Oxygen uptake was closely associated with the concentration of glucose. Separate investigations have shown that the reduction in oxygen utilization was not due to inactivation of the enzyme but to depletion of the glucose.

From the above discussion of the characteristics of the glucose-oxidase-catalase sytsem, it is evident that this enzyme system can be used over a wide range of conditions. The following are some of the uses of this enzyme system.

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 13, 1957.

[b] DeeO.

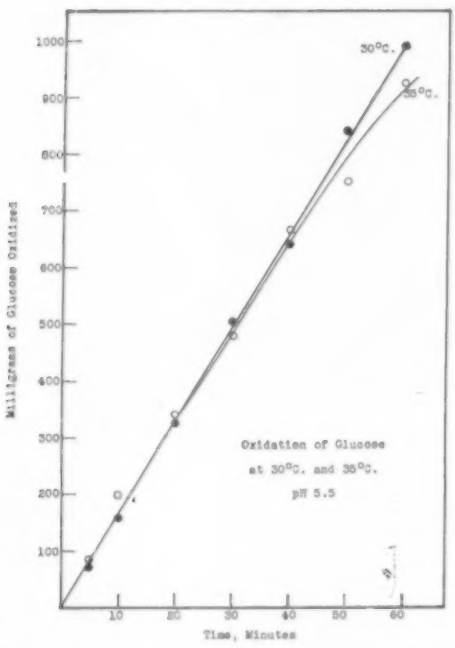

Figure 2. Rate of glucose oxidation from a 3% glucose solution at 30° C. and 35° C. at pH 5.5.

USES

Uses of glucose oxidase-catalase to protect foods

Sugar Removal. At the present time, the best example of the use of glucose oxidase for the removal of glucose is from egg albumin and whole eggs prior to drying.

As has been reported by Baldwin *et al. (2)*, this means of desugaring liquid eggs offers an operation that can be better controlled than the use of bacterial or yeast fermentations. Additionally, there is no development of off-flavors that is characteristic of these latter mentioned procedures. The recommended procedure is to use 50 g. of DeeO glucose oxidase per 1000 pounds of liquid egg albumin or 150 g. per 1000 pounds of whole egg or yolk. It is not necessary to adjust the pH of whole eggs but albumin should be adjusted to pH 7.0 to avoid the separation of mucin. For both types, the reaction temperature is 90° F. Oxygen is supplied in the form of 35% hydrogen peroxide. Best results are obtained if hydrogen peroxide is added in frequent aliquots as recommended by Scott (4) rather than all at one time.

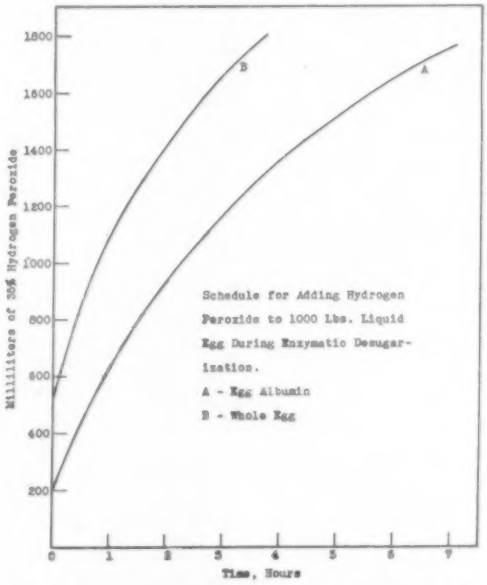

Figure 4. Recommended schedule for the addition of hydrogen peroxide to liquid egg during enzymatic desugarization.

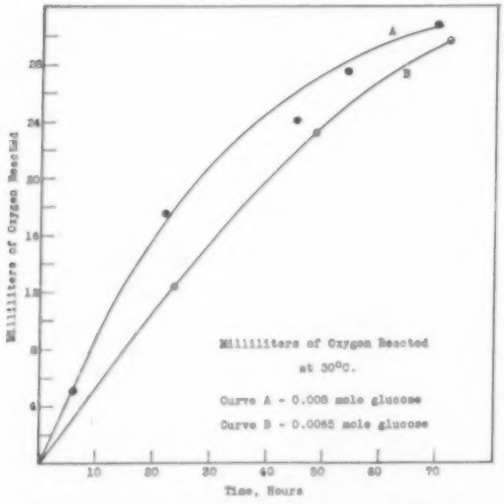

Figure 3. Oxygen uptake in the presence of two levels of glucose.

Glucose removal is deemed complete when negative results are obtained with Somogyi sugar reagent or with Clinistix ®.

Experimentally, the effect of using a higher temperature (40° C.) and one half the quantity of enzyme (75 g./1000 pounds) was investigated. This work was done on whole eggs with no adjustment of pH. From Table 2, it can be seen that at the higher temperature an additional hour was required to com-

TABLE 2

Effect of enzyme concentration and temperature on desurgarization of whole eggs

Temperature	Enzyme concentration		Time for desugarization	
30° C.	150 g./1000 lbs. eggs		2 hours, 45 minutes	
40° C.	75 g./1000 lbs. eggs		3 hours, 45 minutes	
	Plate counts			
Time, hours	0	1.5	3	4
Temperature				
30° C.	137,000,000	29,000,000	28,000,000	.....
40° C.	137,000,000	400,000	.....	95,000

plete desugarization. However, in the case of eggs at least, the combination of the higher temperature and the hydrogen peroxide caused a highly significant decrease in bacterial plate counts.

Oxygen Removal. Oxygen has been responsible for a wide range of deterioration of foods. Chief among these have been flavor and color changes. In acid canned foods, oxygen has accelerated can corrosion.

While somewhat dependent on the constituents of the food it has been used with, glucose oxidase has been effective in protecting foods by the removal of oxygen.

Use in bottled carbonated beverages. Glucose oxidase in a concentration of 10 p.p.m. was added to several flavors of bottled beverages just prior to bottling. Along with untreated control samples, the beverages were held at room temperature for 6 months. At 3- and 6-month intervals, flavor differences were determined by triangular taste tests and the absorption spectra in the visual range were measured. The absorption spectra of 4 different flavors measured after 6 months' storage demonstrate the range of protection afforded by glucose-oxidase. In Figure 5, those of orange soda indicate that the

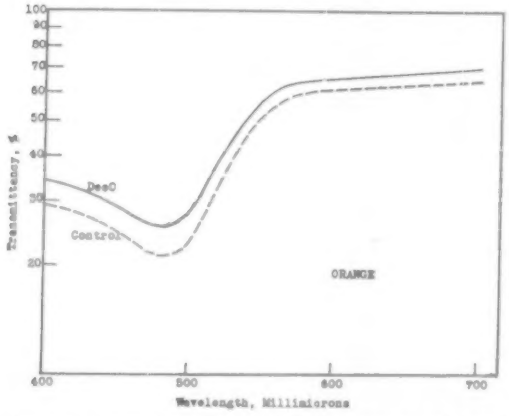

Figure 5. Absorption spectra of bottled orange soda samples after six months storage.

enzyme prevented (or lessened) the darkening of this beverage. The untreated sample had a muddy color whereas that of the enzyme treated sample was the bright typical color of orange soda. Another type of protection is demonstrated in Figure 6. Here it can be seen that glucose oxidase reduced the fading of the color of black cherry soda. Glucose oxidase had no protective action on the color of sassafras soda (Figure 7) but in contrast to the other flavors, there was a significant difference in the flavor of the treated and untreated samples. The flavor of the enzyme treated sample was typical of this type of soda while that of the untreated control was flat and nondescript. Figure 8 shows those of a stable type of grape soda with which glucose oxidase protection was unnecessary for either color or flavor. These 4 samples of bottled carbonated beverages indicate that the removal of oxygen by glucose oxidase and its resultant effect varies with the material with which the enzyme is used.

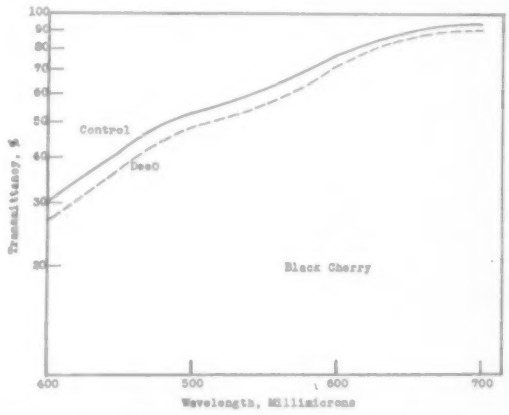

Figure 6. Absorption spectra of bottled black cherry soda after six months storage.

Use in canned carbonated beverages. In canned carbonated beverages, an additional factor is introduced, namely, the pickup of iron from the container by the acid beverage. This corrosion of the container is often great enough to cause perforation of the can. Glucose oxidase in concentrations of 0, 10, 30, and 50 p.p.m. were added to a cola type beverage and black cherry soda packed in 12-ounce containers. These canned beverages were held at room temperature and samples taken for analysis at 1, 3, and 6 month intervals. Iron was determined on degassed composite samples of 3 to 5 cans using the orthophenanthroline colorimetric procedure *(2)*. From Table 3, it can bee seen that iron pickup of the untreated control was the highest of all the samples, while that of the samples containing glucose oxidase was slight. The corrosion of the cans containing un-

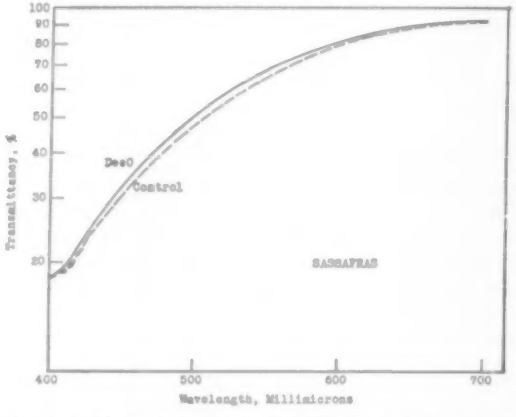

Figure 7. Absorption spectra of bottled sassafras soda after six months storage.

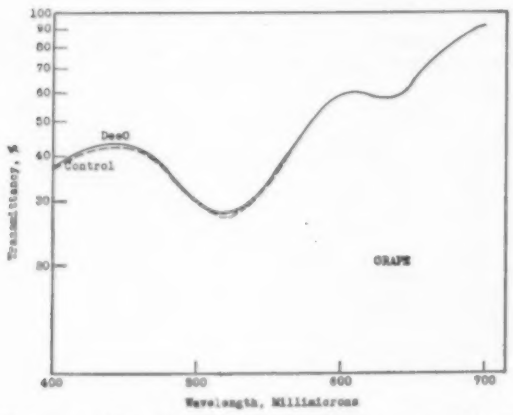

Figure 8. Absorption spectra of bottled grape soda after six months storage.

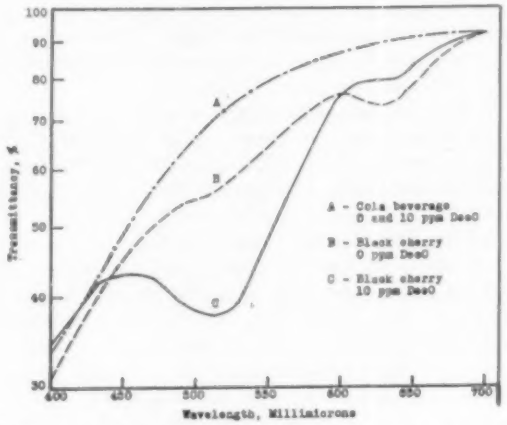

Figure 9. Absorption spectra of canned cola and black cherry soda samples after six months storage.

treated cherry soda was great enough to cause pinholing in some of the cans. Iron pickup was not significant in any of the treated samples until after 6 months' storage. At this time, the iron content of the cola sample containing 10 p.p.m. of glucose oxidase increased.

TABLE 3

Iron content of canned beverages

Flavor	DeeO p.p.m.	Iron, p.p.m., after storage for			
		0 month	1 month	3 months	6 months
Cola	0	0.5	0.8	1.3	2.9
	10	0.5	0.7	1.1	2.3
	30	0.5	0.7	0.5	1.9
	50	0.5	0.7	0.6	1.0
Black Cherry	0	0.3	0.5	1.3	4.5
	10	0.3	0.4	0.9	0.8
	30	0.3	0.5	0.4	1.1
	50	0.3	0.4	0.5	0.5

In Figure 9, it can be seen that the color of the cola beverage was unchanged. However, even the lowest concentration of enzyme (10 p.p.m.) had a considerable stabilizing effect on the color of the black cherry soda. The untreated control sample had undergone a remarkable color change turning from a dark red to a cola-like brown. At all test intervals, there was no significant difference in flavor between the untreated control and enzyme treated samples.

Use in canned beer. Glucose oxidase has found application in stabilizing canned beer by its ability to remove oxygen. In this usage, one half the enzyme (0.25 g./barrel) is added during fermentation and the remainder during the chill proofing step. Over a 6-month interval in both the enzyme treated and bisulfite treated samples, iron pickup was negligible. Oxygen content of the headspace gas was measured with the apparatus described by Zambuto *(5)*. Oxygen pickup by glucose oxidase was considerably greater than that of bisulfite (Table 4). Over a year's storage interval, it can be seen that when glucose oxidase was used as an antioxidant, oxygen pickup was about three times greater than when bisulfite was used.

TABLE 4

Oxygen removal from headspace gas by antioxidants in canned beer

Antioxidant	Oxygen, p.p.m., after storage for		
	1 week	1 month	1 year
Bisulfite	1650	915	195
DeeO	555	346	56

SUMMARY

A study of the characteristics of the glucose-oxidase-catalase enzyme system indicates that it is active over a wide pH range and is stable at relatively high temperatures. Its protective action of foods is dependent on the type of food with which it is used. When used with certain beverages it can protect color and flavor of bottled beverages. When used with canned beverages, it reduces iron pickup and is highly effective in reducing headspace oxygen.

LITERATURE CITED

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2. Continental Can Co., Determination of iron in carbonated beverages (Personal Communication, 1955).
3. Muller, D. Über die sogenannte Glucoseoxydase. *Naturwiss.*, 28, 516 (1940).
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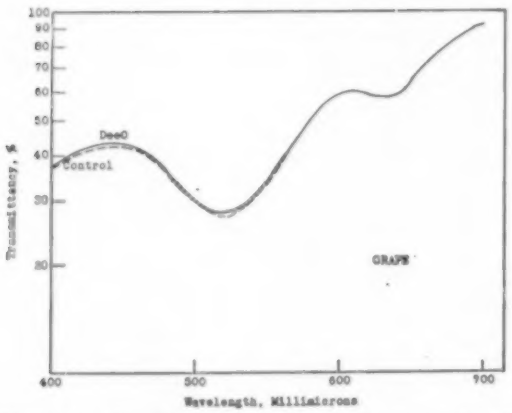
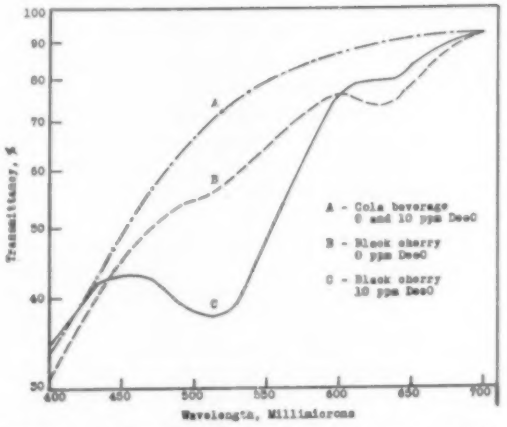


Figure 8. Absorption spectra of bottled grape soda after six months storage.


A - Cola beverage 0 and 10 ppm DeeO
B - Black cherry 0 ppm DeeO
C - Black cherry 10 ppm DeeO
Transmittancy, %
Wavelength, Millimicrons

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	10	0.3	0.4	0.9	0.8
	30	0.3	0.5	0.4	1.1
	50	0.3	0.4	0.5	0.5

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FOOD TECHNOLOGY

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The Professional Society of Food Technologists

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Institute of Food Technologists

THE PROFESSIONAL SOCIETY OF FOOD TECHNOLOGISTS

The Institute of Food Technologists numbers among its active members leading scientists, technologists and engineers in the field of Food Technology.

The Institute invites your professional association with this select group of scientific and technological workers. Only those who are qualified by education, special training, or experience are extended this invitation.

Food Technology may be defined as the application of science and engineering to the production, processing, packaging, distribution, preparation and utilization of foods. Scientists, technologists and engineers engaged in Food Technology, executives, officials and supervisors under whose jurisdiction Food Technology operations are conducted, research investigators, teachers, and others working in the field of Food Technology, will find membership in the Institute worth many times its modest cost.

If you can meet the qualifications for membership, you owe it to yourself and to your business or profession to become a member.

OBJECTIVES

The Institute is a non-profit, professional, educational association to promote the application of science and engineering to the production, processing; packaging, distribution, preparation, and utilization of foods; it stimulates investigations into technological problems arising therein, it provides a medium for presenting and discussing the results of such investigations; it stimulates and provides means for the free interchange of technological information and ideas among food technologists; it promotes recognition of the role of food technologists in the technical direction of operations in these fields; all of these activities have the ultimate objective of providing better and adequate foods for mankind.

ORGANIZATION AND PROGRESS

Organized July 1, 1939, at Cambridge, Mass., with a membership of less than 100, the Institute has grown to more than 4,900 (1956). It is world-wide in scope, with members in North, Central, and South Americas, the Scandinavian countries, England, Holland, Germany, France, India, Australia, and New Zealand.

MEMBERSHIPS

Professional Members. Any person who is ethically qualified, and who has had training and experience in food technology, or any person who in the opinion of the Council is recognized as distinguished in the contributing sciences as they apply to foods, shall be eligible to be a Professional Member of the Institute. The minimum training which shall qualify a candidate for eligibility for Professional Member is, in general, graduation from a college, university, or similar institution in which he has majored in one or more of the sciences or branches of engineering associated with food technology. The minimum experience shall be three years experience in food technology. The Council may, at its discretion, waive any or all of the foregoing requirements in the case of a person who, thru long experience has distinguished himself in the field of food technology.

Members Any ethically qualified person, active in special or limited aspects of food technology, who is an administrator, director or executive under whose jurisdiction operations in food technology are conducted; or who is engaged in the dissemination of knowledge of food technology; or one whose work requires a general knowledge of the broad principles of food technology as it applies to the products, processes or equipment with which he or she is concerned; or one scientifically trained in and who has entered a career in food technology; shall be eligible to become a Member.

Student Members. Any ethically qualified person who has never been a Professional Member or Member of the Institute, who is registered as a student in an educational institution with at least Junior (third year) standing, who is a candidate for a Bachelor's or higher degree in one or more of the sciences or branches of engineering associated with food technology, shall be eligible for membership as a Student Member. This classification shall be his status only until the end of the calendar year in which he completes his schooling. When graduated and otherwise qualified as defined in the section on "Members," a Student Member may, upon application, be elected to Membership.

DUES

Professional Members and Members—$7.50 per year; Students—$2.50 per year. Dues include a subscription to Food Technology.

PUBLICATIONS

Food Technology, issued monthly, is the official journal of the Institute. It is published to advance the profession of food technology by disseminating the results of research and their practical application in industry. Contributors to its pages represent many fields of scientific and technological interest.

Food Research, published bi-monthly, is devoted to publication of the results of original investigations and occasional reviews in the fields of food and beverage technology, chemistry, and microbiology. Food Research is available to Institute members at the special rate of $7.50 per year.

REGIONAL SECTIONS

Where sufficient members (25 or more) live within commuting distance of a given point, a Regional Section may be established. Such Sections are able to hold meetings at more frequent intervals than the National group, thus affording the food technologists regular opportunities for an xechange of views and ideas with others in the area. There are presently 28 Regional Sections.

ANNUAL MEETINGS

Each year one of the regonal sections acts as host to the Institute at an annual meeting. The program of this annual conference is designed to acquaint members with various phases of food production, processing and distribution, and to keep them abreast of current trends and technological developments. The speakers invited are those whose subjects will build a well-rounded program, of interest to the greatest number. Annual conferences are highlighted by exhibits of new equipment, processes and special ingredients.

AWARDS

The society administers the following awards:

NICHOLAS APPERT AWARD (Medal). Each year the Chicago Section of the Institute makes this award to a person whose contributions to the food industry make him distinguished and outstanding in the opinion of the national jury.

BABCOCK-HART AWARD ($1,000.00). The purpose of this award, made by the Nutrition Foundation, is to encourage contributions to Food Technology which will have an influence on the nutritional well-being of the general population.

FLORASYNTH FELLOWSHIP AWARD. $1,000 granted annually to a young man or woman under 35 years of age, engaged in senior undergraduate or graduate work, as a candidate for an advanced degree, in recognized educational institutions in the United States or Canada, which is conducting fundamental investigations for the advancement of Food Technology.

GENERAL FOODS FELLOWSHIP AWARDS. Three Fellowships will be granted annually—no more than two to the same educational institution for the same calnedar year, but will be renewable upon application to and approval by the Awards Committee of the Institute for a maximum of three years, in order to provide for continuity of studies leading to a doctorate degree. if the candidate so plans. However, candidates who plan only a year of research after obtaining the Bachelor Degree, or who plan to read for a Master's Degree, will not be excluded from these fellowship grant. Each Fellowship is worth approximately $4,000.

GERBER BABY FOODS SCHOLARSHIPS. Six undergraduate Scholarships at $1000 each, per year, intended to cover the last two school years leading to a Bachelor's degree in Food Technology, Food Engineering, or Food Science.

NEW EDITION

The Vital Story of MILLED WHITE RICE

Enriched with Vitamins and Iron for Better Health

by Science Writer

A second "Battle of Bataan" in the Philippines has proven beyond all doubt the value of vitamin enrichment to consumers of white rice.

The famous Bataan experiment in 1948-1950 proved conclusively that whole populations can benefit from enrichment of white rice with vitamins and iron, that disease and death caused by dietary deficiencies can be overcome, that enrichment is a key to better health among infants, children and adults.

What Happened at the Second "Battle of Bataan"

Before the start of the Bataan trial, these facts were evident:

- Polished white rice is the principal food of millions throughout the world. Good food though it is, it lacks several of the key nutrients occurring in the brown rice from which it is milled, and beriberi is often common where white rice is the main food.
- In the Philippines, beriberi was common and mortality from it high.
- Beriberi is caused by insufficient vitamin B_1 in the diet. It yields when vitamin B_1 is given to its victims. It does not occur when human beings receive enough of this vitamin in their diet.
- To prevent beriberi where white rice is the the main food, vitamin B_1 must be added to the diet, either by itself or in food such as rice.

- For centuries it has been universal practice to rinse rice before cooking, hence vitamin B_1 (and any other water-soluble nutrient factor) should be added in such a way that it will not dissolve out.
- Through a process developed in the laboratories of Hoffmann-La Roche, it is possible to enrich white rice with water-soluble vitamins and iron so they will not wash off during this rinsing prior to cooking.

With these facts known, the second "Battle of Bataan" began. Through the cooperation of Philippine public agencies, the Williams-Waterman Fund, the USPHS, and Hoffmann-La Roche a controlled experiment was set up in the province of Bataan. More than 12,000 medical examinations were made, before the enrichment of rice began. Nearly 13% of those examined had beriberi.

Enriched white rice was then put into commerce in the experimental area, but not in the control area.

What happened? *Within two years beriberi was practically wiped out in the experimental zone!* . . . beriberi mortality dropped almost to zero . . . almost 90% who had symptoms of the disease before enrichment's start were free from signs of the disease or were greatly improved . . . thousands of people were helped to better health. News of the success of enrichment reached people in the control area and caused them to demand that their rice be enriched, too.

Other Countries Follow Suit

Word of the excellent results of the Bataan experiment fanned out throughout the world. The largest rice miller in Thailand marketed enriched white rice with success in 1951. In that year, also, the Puerto Rican government enacted legislation requiring that all white rice sold there be enriched, beginning early in 1952. Since then, enriched rice has been made available to the public in Cuba, Venezuela, Colombia, The Dominican Republic, Taiwan (Formosa), Singapore, and Australia.

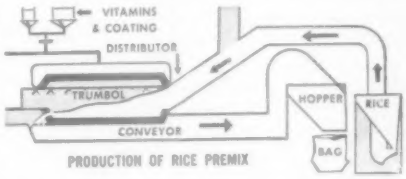
South Carolina Adopts Rice Enrichment

South Carolina, a state having very high per-capita white rice consumption, passed a law in the spring of 1956 requiring that all white rice sold within the state after July 1 be enriched with vitamin B_1 (thiamine), niacin, and iron, and it is hoped to include riboflavin (vitamin B_2) at a later date. South Carolina is the first state in the USA to enact rice enrichment legislation; it has required enrichment of white flour and corn meal since 1942 and 1943 respectively.

How is White Rice Enriched?

The enriching method in widest use throughout the world employs a method developed in the laboratories of Hoffmann-La Roche Inc., pioneers in the research and production of vitamins.

The Roche method impregnates rice grains with thiamine, niacin, riboflavin if desired, and iron and adds a final, outer coating of edible material to protect the vitamins against deterioration and preliminary washing and rinsing. For economy large amounts of vitamins are applied to small amounts of rice to make a "premix" and one pound of this "premix" is then mixed with a larger quantity (usually 199 lbs.) of ordinary milled white rice at the rice mill. As required in Philippine and Puerto Rican legislation, U. S. Federal Specification N-R-351C and South Carolina regulations for bulk (bags of 50 or more pounds) white rice, each pound of this nutritionally-improved rice provides not less than 2.0 mg. of thiamine, 16 mg. of niacin, and 13 mg. of iron and 85% of these levels are assuredly present after a prescribed rinsing test. In some countries, riboflavin also is included.



PRODUCTION OF RICE PREMIX

Other methods of enriching are permitted by the South Carolina statute. Small amounts of rice packaged for retail sale may have the vitamins and iron present as a powder which clings to the individual rice grains, or a liquid spray can be used. These packages must be labeled: "Do not rinse before or drain after cooking."

The Federal Food and Drug Administration in December of 1956 published proposed definitions and standards of identity for enriched rice. These standards, currently under discussion, provide for vitamin levels along the lines of Puerto Rican and South Carolina requirements.

What of the Future?

The trend to nutritionally-improved foods for better health is definite. The United States, a world-leader in the enrichment of white flour, white bread, corn meal and grits, farina, pastina, macaroni products, and breakfast cereals is now recognizing the need to enrich milled white rice. *When good foods are made better, everyone benefits.*

This article is part of series on the enrichment of processed cereal grain foods which are enriched for better nutrition. It is published by the Vitamin Division, Hoffmann-La Roche Inc., Nutley 10, New Jersey. An illustrated brochure containing the text of all articles in the series is available at your request without charge.

ABSTRACTS

(Continued from page 35 preceding technical papers)

48 hrs. Rapid hydroxyproline production in such scorbutic animals upon the administration of ascorbic acid may be due to the conversion of an accumulated pool of protein material, rich in proline and glycine, to a more immediate collagen precursor rich in hydroxyproline.

Cholesterol biosynthesis: the starvation block.

SCAIFE, J. F. AND MIGICOVSKY, B. B. (Canada Dept. of Agriculture, Ottawa). *Can. J. Biochem. Physiol. 35*, 615–23 (1957).

The failure of liver homogenates, from starved rats, to incorporate acetate into cholesterol has been previously demonstrated. This exptl. evidence indicates that this block is located in the biosynthetic pathway between β-hydroxy-β-methylglutaric acid and squalene. There appears to be no evidence for an accumulation of some intermediate owing to the blocked cholesterogenesis.

A possible mechanism for fatty acid inhibition of cholesterol synthesis.

WOOD, J. D. AND MIGICOVSKY, B. B. (Canada Dept. of Agriculture, Ottawa). *Can. J. Biochem. Physiol. 35*, 645–53 (1957).

A correlation appears to exist between cholesterol as biosynthesis inhibition and the elongation of the C chain of satd. fatty acids contg. an even no. of C atoms. The stage where acetoacetate is formed from acetyl Co-A is suggested as a possible site for the inhibition.

Saturated fatty acids as bacterial antimetabolites.

CAMIEN, M. N. AND DUNN, M. S. (Univ. of California, Los Angeles). *Arch. Biochem. and Biophys. 70*, 327–45 (1957).

Inhibitory effects of satd. fatty acids of from 7 to 24 carbons in length on nine species of lactic acid bacteria have been investigated. The inhibitions due to the acids of from approx. 12 to 20 carbons in length (depending on the test organism) have been shown to be the result of a potent antimetabolite effect, readily reversible by any of the six unsatd. fatty acids (oleic, linoleic, ricinoleic, vaccenic, lieanic, and erucic acids) and the one cyclopropane acid (lactobacillic acid) tested. The inhibitions due to satd. fatty acids of longer chain length (22 and 24 carbons) nearly equal those of the most active satd. acids in the 12- to 20-carbon range. A scheme of metabolic pathways suggested by the present findings and correlating the latter with earlier data concerning bacterial lipide metabolism is proposed.

The carotenoids of tangerines.

CURL, A. L. AND BAILEY, G. F. (Western Utilization Research Branch, Agricultural Research Service, U.S.D.A., Albany 10, Calif.). *J. Agr. Food Chem. 5*, 605–8 (1957).

The carotenoids in tangerine peel and pulp (fruit flesh) have been fractionated by countercurrent distribution, followed by chromatography. Factors contributing to the redder color of the tangerine, as compared to the orange, were much higher concns. of cryptoxanthin (pulp and peel), β-carotene (pulp), and a hydroxy-canthaxanthin-like substance (peel). Minor constituents not previously reported from oranges included lycopene, γ-carotene-like and hydroxycanthaxanthin-like fractions from the pulp, and lycopene and a rubixanthin-like fraction from the peel. A minor phytofluene-like band was found on chromatography on the column between α-carotene and β-carotene, in both pulp and peel carotenoids.

Microbiology

Food perishability: The determination of the vulnerability of food surfaces to bacterial infection.

CLAYSON, D. H. F. AND BLOOD, R. M. (Lyons Labs., Cadby Hall Kensington, W. 14). *J. Sci. Food Agr. 8*, 404–14 (1957).

A technique has been devised whereby the limiting conditions of equil. relative humidity (e.r.h.), and consequently of osmotic pressure, for bacterial growth can be demonstrated, using bacteria in thin films. With *Salmonella typhimurium* and *Escherichia coli* Type I, growth is prevented at and below an e.r.h. of 92% and with *Staphylococcus aureus*, at or below 85%. By a modification of the technique a heterogeneous article of food can be dissected and the vulnerability of the different parts of the growth of bacterial infection can be detd.

A bacteriological survey of commercially frozen beef, poultry and tuna pies.

LITSKY, W., FAGERSON, I. S., AND FELLERS, C. R. (Univ. of Massachusetts, Amherst). *J. Milk and Food Technol. 20*, 216–19 (1957).

The results of a bacteriological survey of commercially packed tuna, chicken, turkey, and beef frozen pies on a nationwide scale is reported. Samples were collected at the retail store level and exaind. for total count, enterococci, coliform and Salmonella type organisms. It is proposed that the total count be used as a sanitary index. An initial bacteriological standard of 100,000 organisms per gram is recommended on a tentative basis.

Sparing of cellulose by amino acids among aerobic soil bacteria.

HULCHER, F. H., YOUNG, R. W. AND KING, K. W. (Virginia Agr. Expt. Sta., Virginia Polytechnic Inst., Blacksburg). *J. Bacteriol. 73*, 703–5 (1957).

Measurement of ammonia liberation, cellulose decompn. and growth of an unselected group of 41 aerobic, cellulolytic, soil bacteria in media with nitrate of casein hydrolyzate as sole source of N showed that amino acids exerted a sparing action on cellulose in 36 of these cultures.

Nutrition

Nutritional improvement of white flour with protein and amino acid supplements.

DESPHANDE, P. D., HARPER, A. E. AND ELVEHJEM, C. A. (Univ. of Wisconsin, Madison). *J. Nutrition 62*, 503–12 (1957).

Rate of growth of young rats was increased from 3 to 21 g./wk. when their diet, contg. 78% of white flour was supplemented with 0.5% of L-lysine and 0.4% of DL-threonine. Maximum growth was obtained when intact protein formed part of the supplements but growth was not as rapid when the protein was replaced by equivalent quantities of cryst. essential and non-essential amino acids.

Studies on the protein quality of high-oil, high-protein corn.

REUSSNER, G. AND THIESSEN, R. (Research Center, General Foods Corp., Tarrytown, N. Y.). *J. Nutrition 62*, 575–84 (1957).

Two high-oil, high-protein corn varieties (13.0% protein with 8.6% oil and 11.5% protein with 7.0% oil) gave significant increases in growth and protein quality over that obtained from regular corn (9.3% protein with 5.1% oil) in ad libitum feeding with rats. When the protein levels were adjusted to 7.5%, no significant differences in growth or protein quality were shown by the high-oil corns over the corn. On an equal protein level of 7%, grits from one of the high-oil samples (8.6% oil) did not show significant differences in growth or protein efficiency when compared to a sample of regular corn grits. When fed at 12% protein levels, the germ from regular corn gave significantly better growth and protein efficiency than did the high-oil variety. Microbiological amino acid analyses correlated rather well with rat growth tests. However, a corn germ sample contg. high oil resulted in poorer growth and protein efficiency than regular corn germ which seemed to have a poorer amino acid pattern including a lower level of lysine.

Flavonoids in human nutrition and medicine.

PEARSON, W. N. (Vanderbilt Univ. Sch. of Med., Nashville, Tenn.). *J. Am. Med. Assoc. 164*, 1675–7 (1957).

The high hopes once held for the flavonoids as important metabolites have not materialized. Instead, present knowledge indicates that, while they possess mild pharmacological properties under certain conditions, the flavonoids have no known nutritional functions. They cannot be regarded as essential nutrients.

Ascorbic acid and bioflavonoids.

Nutrition Revs. 15, 209–10 (1957).

Studies on 89 medical students and student nurses showed the administration of a bioflavonoid had effect neither on the incidence or cure of colds nor on the ascorbic acid level in the blood.

Overnutrition for the child: Blessing or curse?

Nutrition Revs. 15, 193–6 (1957).

Recent surveys indicate that 10% of the child population may be classed as overweight suggesting that overnutrition rather than undernutrition may be the therapeutic problem for modern pediatricians. Studies indicate that over supplementation, particularly with vitamins, may be the key to such diseases as hypercalcemia in infancy from which overdosage of vitamin D cannot be eliminated as a possible factor. There are indications, in reference to vitamin D overdosage, that a segment of the British infant population may be receiving 10 times its minimal requirements of vitamin D due to overfortified milk, cereal and high vitamin D content cod liver oil. Toxicity of vitamin A and K overdosage is also discussed. The author states that we can no longer conclude that max. growth is optimum nutrition.

Physiologic results of breakfast habits.

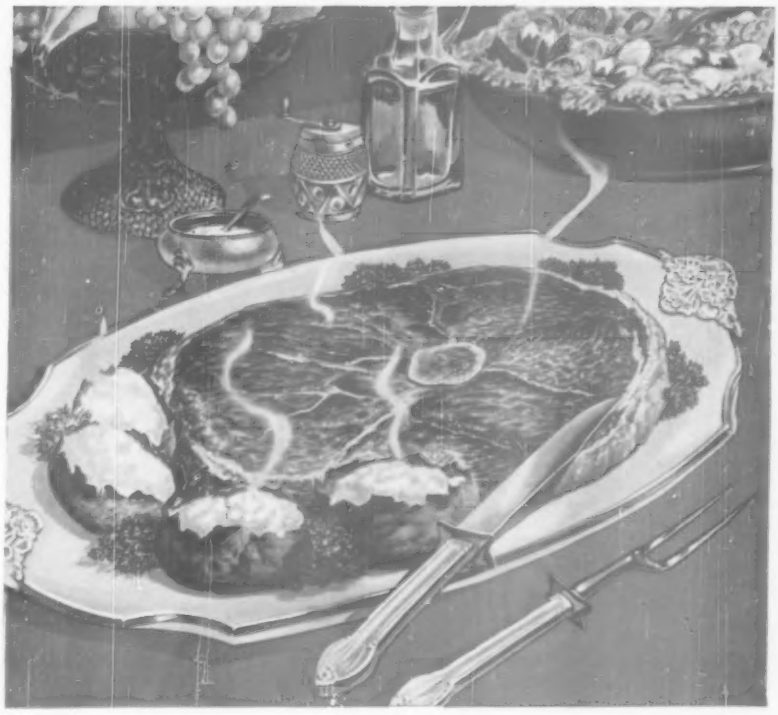
Nutrition Revs. 15, 196–8 (1957).

Well controlled recent studies with various age groups showed that omission of breakfast resulted in a decrease in max. work output, an increase in neuromuscular tremor magnitude, and choice reaction time and a decrease in max. grip strength and grip strength endurance along with an increase in the amt. of oxygen required to perform a specified amt. of work. Breakfast content made no difference in the physiologic responses in late morning hours when two breakfasts, one built around cereal and milk and the other based upon bacon, eggs, and milk were fed. Data showed that a breakfast contg. 0.25 the daily caloric requirement and protein allowance is to be preferred to a heavy breakfast.

Utilization of food for weight maintenance and growth.

KAUNITZ, H., SLANETZ, C. A. AND JOHNSON, R. E. (Dept. of Pathology, Columbia Univ., New York). *J. Nutrition 62*, 551–9 (1957).

Food requirements for wt. maintenance and wt. increase were detd. by measurements of the food intake of rats kept at const. wt. by restricted feeding of a complete, purified diet and of the food intake and wt. increase of well-matched rats permitted to eat freely of the same diet. The requirements for the maintenance of one gram of body wt. were found to be influenced by the duration of food restriction, the body wt., and the room temp. but hardly by the age of the animals, whereas, food requirements for wt. increase did not seem to be influenced by the above factors. Approximately 1 g. of food was necessary to build 1 g. of body substance under widely different conditions. The implications of these findings for studies of food



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utilization and paired weighing and paired feeding techniques are discussed.

Potentiating effects of materials of plant and animal origin on symptoms of hypervitaminosis A in the rat.

ERSHOFF, B. H., HERNANDEZ, H. J. AND MUCKENTHALER, J. M. (Univ. of Southern California, Los Angeles). *J. Nutrition 62*, 527–38 (1957).

Immature rats were fed a purified ration contg. a massive but relatively nontoxic dose of vitamin A. Supplements of alfalfa meal and other succulent plants resulted in a significant potentiation of the symptoms of hypervitaminosis A. Both the dried alfalfa juice and the water-washed pulp remaining after the extn. of the juice were active in this regard. Desiccated liver, yeast, a product derived from fermentation sources and aureomycin HCl also showed activity. In contrast to the above, supplements of all the known nutrients had little if any potentiating effects.

Effect of relative humidity on rat breeding and ringtail.

NJAA, L. R., UTNE, F. AND BRAEKKAN, O. R. (Governmental Vitamin Lab., Norwegian Fisheries Research Inst., Bergen). *Nature 180*, 290–1 (1957).

Ringtail and high mortality rate of new-born rats occurred mainly in the winter. The authors have correlated these cases to the low relative humidity of the breeding rooms while being heated. Raising the humidity reduced the number of cases. It is believed that reduced humidity increases the heat loss of the naked new-born due to evapn. By reducing the flow of blood to the tail, the heat-loss is cut down but ringtail develops.

The non-essentiality of fluorine in nutrition.

MAURER, R. L. AND DAY, H. G. (Indiana Univ., Bloomington). *J. Nutrition 62*, 561–73 (1957).

The investigation has demonstrated that under the rigorous exptl. conditions employed, fluorine is not a dietary essential. Its value in the body is apparently limited to the promotion of resistance to dental caries.

Symposium on fats in human nutrition.

J. Am. Med. Assoc. 164, 1890–1925 (1957).

Papers presented at the symposium "Fats in Human Nutrition" in New Orleans, March 15, 1957 are as follows: Dietary fat, its role in nutrition and human requirements. Some biochemical aspects of lipid and lipoprotein metabolism. Pathological lesions related to disturbances of fat and cholesterol metabolism in man. Dietary control of serum lipids in relation to atherosclerosis. Diet and the epidemiology of coronary heart disease. Nutritional studies relating to serum lipids and atherosclerosis.

Properties of substances in gelatin which stimulate the growth of chicks fed amino acid diets.

BENTON, D. A., SPIVEY, H. E. AND ELVEHJEM, C. A. (Univ. of Wisconsin, Madison). *Arch. Biochem. and Biophys. 70*, 491–8 (1957).

Fractionations of an acid hydrolyzate of gelatin were carried out and the fractions assayed for growth-stimulating activity with chicks fed amino acid diets. The growth-stimulating activity was not extd. with *n*-BuOH; was partly extd. with phenol; was not pptd. by basic Pb acetate or phosphotungstic acid; was not taken up by Amberlite IR4B; but was taken up by Dowex 50 and eluted with acid. The properties of the active materials are discussed.

Observations on the urinary amino acid excretion in man: the influence of age and diet.

FOWLER, D. I., NORTON, P. M., CHEUNG, M. W. AND PRATT, E. L. (New York Univ. Coll. of Med., New York). *Arch. Biochem. and Biophys. 68*, 452–66 (1957).

In terms of creatinine excretion it was found that premature infants excrete roughly ten times as much free amino acid as do subjects ten or more years old, and that full-term infants excrete roughly three times as much as the older subjects. Our data on 10-year olds reveal values virtually identical with those reported for adults. The pattern of individual amino acid excretion was found to differ in early life from that seen in older children and adults. A no. of amino acids are present in greater amt. and several are found only at that time of life. The effects of diet on amino aciduria are considered, the indications being that the amino acid output in the urine is influenced to some extent by the diet.

Pharmacology and Toxicology

Food poisoning outbreaks associated with spray-dried milk—an epidemiologic study.

ARMIJO, R., HENDERSON, D. A., TIMOTHEE, R. AND ROBINSON, H. B. (Sch. of Med., Univ. of Puerto Rico). *Am. J. Public Health 47*, 1093–100 (1957).

Described are a series of nineteen outbreaks of gastroenteritis occurring during a one-month period among school children. Epidemiologic study and a human volunteer expt. implicated spray-dried milk solids.. Though bacteriologic and toxicologic tests were negative, clinical and epidemiologic evidence indicated that staphylococcal enterotoxin was the probable agent.

Physiology and Medicine

Tissue changes in old age. Similarities and differences in man and laboratory animals.

ANDREW, W. (Winston-Salem, North Carolina). *Geriatrics 12*, 433–8 (1957).

Age changes in man and lab. animals show many similar patterns. The general nature of these changes is shown histologically to be a primary degeneration of the parenchyma with secondary replacement by adipose or fibrous connective tissue.

Control of odor, dermatitis, and ulceration from ammoniacal urine with DL-methionine.

BERGMAN, M. (Newark State Sch., Newark, N. Y.). *Geriatrics 12*, 386–8 (1957).

This problem can be controlled by the administration of 0.6 g. DL-methionine 1/day orally. The rationale appears to be based on the reversal of negative N balance.

FOOD AND FOOD TECHNOLOGY

Confections and Desserts

Relaxation of stress in starch jelly candy.

STERLING, C. (Univ. of California, Davis). *Cereal Chem. 34*, 238–45 (1957).

The rate of relaxation of stress in a starch confectionery jelly has been ascertained with a continuously recording instrument. One-day-old gel samples have been compressed to various degrees of strain for varying periods of time. Relaxation of the stress does not follow a Maxwellian curve (i.e. a curve for a simple Maxwell model). Limiting values of stress indicate a residual elastic response for which a modulus can be calcd. The time of relaxation and the ultimate stress attained vary with the amt. of strain imposed. Elastic properties of the gel det. the value of the ultimate stress and of the stress at any particular time during the period of strain. The mech. behavior of the starch gel does not follow the superposition principle. Molecular changes are interpreted in the light of exptl. results.

Dehydration

Microwave energy in freeze-drying procedures.

COPSON, D. A. AND DECAREAU, R. V. (Raytheon Manufg. Co.). *Food Research 22*, 402–3 (1957).

The use of microwave energy permits the rapid dehydration of certain products not easily handled by conventional processes. Heat is supplied directly to the inner ice vol. because of the penetrating nature of energy at this frequency (2450 mc.). Cuts of meat can be dried in 2/3 less time than formerly possible and without loss in quality.

Fish

Oxidative deterioration in fish and fishery products. Part II. Progress on studies concerning mechanism of oxidation of oil in fish tissue.

BROWN, W. D., BENOLIA, A. W., TAPPEL, A. L., OLCOTT, H. S. AND STANSBY, M. E. (U. S. Fish and Wildlife Service,

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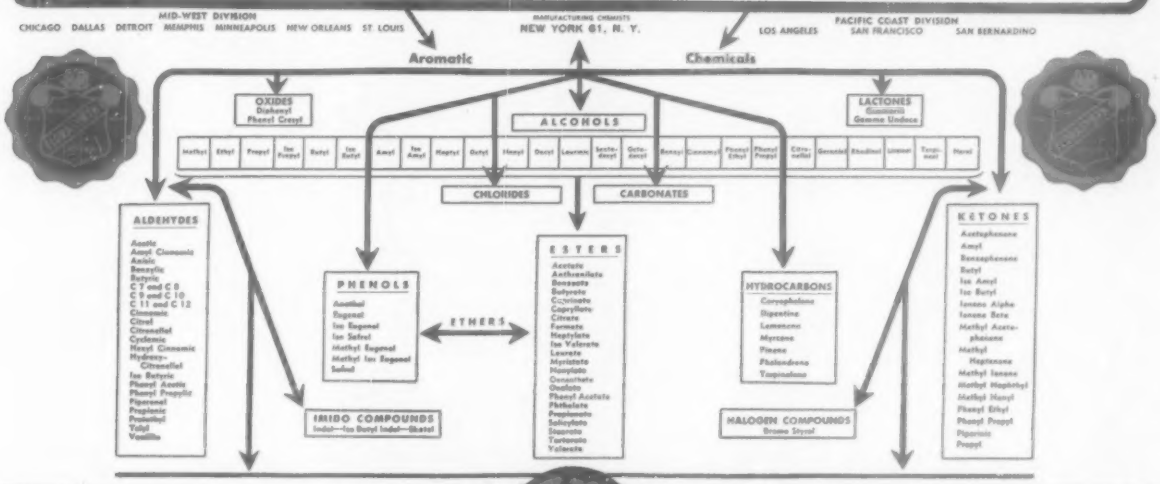

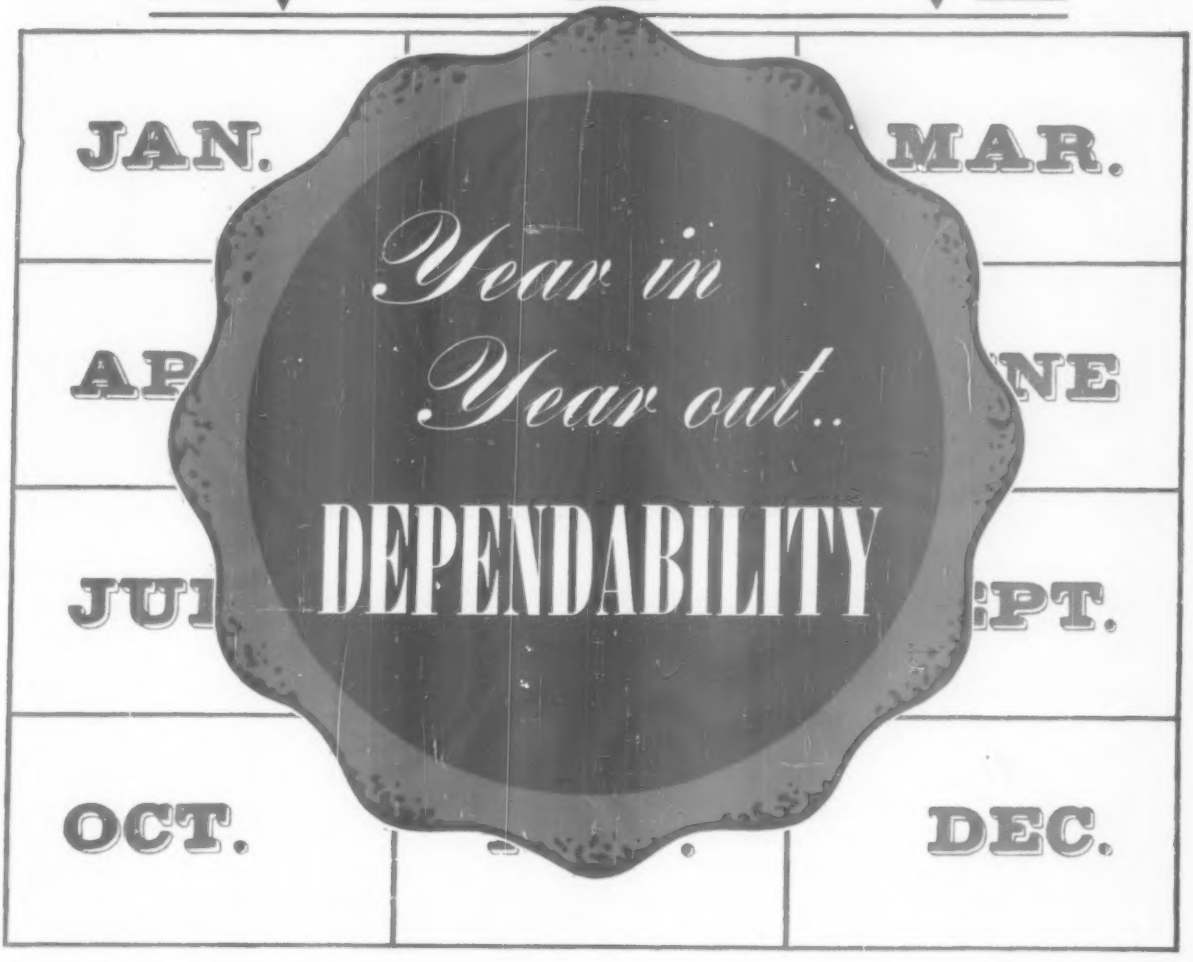

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Seattle, Wash.). *Com. Fisheries Rev. 19*, 27–31, May 1957.

Studies showed that the mechanism of oxidation of fish oils in the meat of fish or in fish meal differs from that of extd. oils owing to the activity of biocatalysts in the tissues. The fish meat content and activity of hematin, found to be the primary catalytic agent in such oxidation, was studied. Activities of the proteins of the meat were found to be of lesser importance. Studies were made on naturally-occurring and commercial antioxidants. A mixt. of the natural antioxidants citric acid, ascorbic acid, and tocopherol was found to be 80 times as effective, owing to synergism, than was citric acid or ascorbic acid alone. Method of addn. of the antioxidant to the test system was found to be of importance in retarding oxidation.

Fruits and Vegetables

Effects of chlorinated hydrocarbon insecticides on flavors of vegetables.

Birdsall, J. J., Weckel, K. G. and Chapman, R. K. (Univ. of Wisconsin, Madison). *J. Agr. Food Chem. 5*, 523–6 (1957).

Lindane treatment caused considerable damage to the flavor of most of the crops studied. Other insecticides had a less pronounced effect. Changes in flavor were more pronounced in canned samples than in new or cooked samples.

Amino acids in nine frozen vegetables.

Murphy, D. M., Kline, B. E., Robbins, R. N., Teply, L. J. and Derse, P. H. (Wisconsin Alumni Research Foundation, Madison, Wis.). *J. Agr. Food Chem. 5*, 608–9 (1957).

Ten amino acids (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine) were dctd. on composites of 102 sets of samples, representing 1953 and 1954 production seasons for nine frozen vegetables. Sample packages were taken from com. processing lines of freezing plants in all United States production areas.

Milk and Milk Products

Spreadability and hardness of butter. I. Development of an instrument for measuring spreadability.

Huebner, V. R. and Thomsen, L. C. (Univ. of Wisconsin, Madison). *J. Dairy Sci. 40*, 834–8 (1957).

An instrument was developed more sensitive than consumers in detecting differences in the spreadability of butter. The results agreed closely with those obtained from consumer-preference studies.

Pectin

Recent advances in the enzymatic hydrolysis of pectic substances.

Demain, A. L. and Phaff, H. J. (Univ. of California, Davis). *Wallerstein Lab. Communs. 20*, 119–39 (1957).

Classification of pectic enzymes into a single logical system, discussion of present status of protopectinase and fungal polygalacturonase and review of microbial and plant pectinesterases.

Starches

Protective starch matrix for xanthophyll oil and vitamin A.

Maywald, E. C. and Schoch, T. J. (Corn Products Refining Co., Argo, Ill.). *J. Agr. Food Chem. 5*, 528–31 (1957).

Oxygen-sensitive materials such as corn xanthophyll oil, vitamin A, or white P can be protected against air oxidation by emulsifying the materials in a cooked paste of a suitable modified starch, and drying the emulsion as a thin film or flake. The starch base must be a good protective colloid and must give molecularly dispersed solns., free from swollen granules or retrograded starch. Suitable starch types include hydrolyzed cornstarch of 5 to 20 dextrose equivalent, high-soluble canary dextrins, thin-boiling waxy starches, and thin-boiling oxidized or etherified starches.

INDUSTRY PUBLICATIONS

The Fatty Acid Composition of Food Fats and Oils, just published by the American Meat Institute Foundation, 939 E. 57th St., Chicago 37, is a handbook of authentic information on the composition of food fats. The author, Dr. L. R. Dugan, Jr., chief of the Foundation's organic chemistry division, has sought to provide a simplified, broadly understandable discussion of what is an unavoidably technical subject. Copies can be obtained by writing H. A. Armstrong, chief of the Foundation's Division of Information and Service.

A liquid, vegetable-oil ester emulsifier, Sole-onic PGE, is described in Technical Bulletin 957–1, published by Sole Chemical Corp., 27 E. Monroe St., Chicago 3. The product can be used as an emulsifier for edible oil compositions; an anti-foamer in sugar cooking systems; an anti-corrosion agent in water-containing aerosols; and a wetter-sticker adjunct for agricultural sprays.

Complete information on **industrial instrument accessories** and supplies has been compiled in a new 60-page catalog available from the Foxboro Co., Foxboro, Mass. The loose-leaf book, Catalog 500, includes specifications, part numbers and prices for more than 250 commonly furnished instrument parts and supplies.

Bacterial Food Poisoning and Its Control by W. B. Esselen and Arthur S. Levine is available to readers of Food Technology by addressing the bulletin editor, Munson Hall Annex, University of Massachusetts, Amherst, Mass.

A data sheet describing the properties and uses of **Hodag Antifoam F-20** for food processing applications is available from Hodag Chemical Corp., 7247 N. Central Park, Chicago 45. The product is designed for prevention of foam in potato and tomato peeling and washing, blanching operations, and in general processing and canning of a variety of vegetables and fruits.

Superlose and Ramalin New Products Bulletin describes the physical and chemical properties of these two principal components of potato starch. Copies can be obtained from the Colloid Dept., Stein Hall & Co., 285 Madison Ave., New York 17.

A complete line of **geared flexible couplings** is illustrated and described in Book 2775, a 12-page bulletin published by Link-Belt Co., Prudential Plaza, Chicago 1. Included are pertinent application and selection data for couplings with maximum bores ranging up to 7 in. and ratings from 2½ to 572 h.p. per 100 r.p.m.

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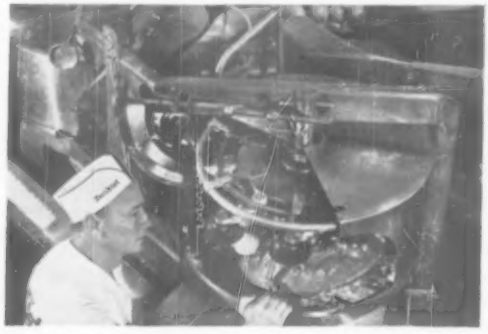

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Exchange quality is assured by constant checking in extensive testing laboratories. In fact, rigid quality controls have been set up *throughout* the plant to make sure that every product measures up to Exchange quality. Sunkist produces more than 400 different citrus products.

The world's largest citrus research department is maintained by the Sunkist Growers to develop new growing methods, to improve manufacturing processes, and to perfect better products. Today, with a backlog of more than 60 years experience, Sunkist has accounted for 118 separate U.S. patents.

Just three of many Exchange products are *Exchange Preserver's Pectin*—guarantees a more uniform finished product; *Exchange Low Methoxyl Pectin*—jells *without* sugar, tasteless, controls "weeping" in pies; *Exchange Lemon Juice*—brings out natural flavor of *any* food. Superior acidulant, excellent anti-oxidant.

Sunkist Growers

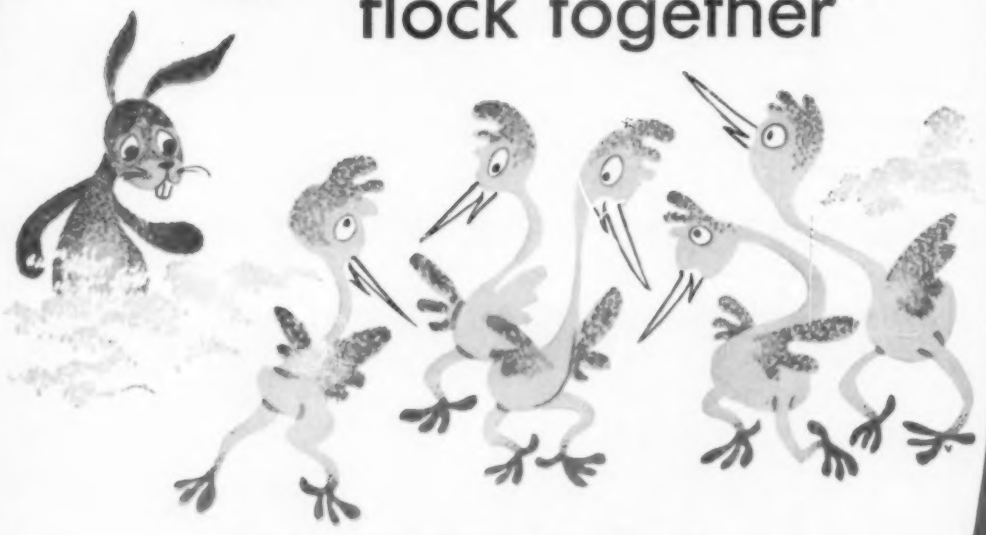
PRODUCTS DEPARTMENT • ONTARIO, CALIFORNIA

Distributors for

Exchange Lemon Products Co., Corona, Calif. • Exchange Orange Products Co., Ontario, Calif.

PROVERB PRATTLE

"Birds of a feather flock together"



The source of this goes back to the "Book of Wisdom" by Ben Sira written about 190 B.C. Numerous variations appear in "Promos and Cassandra" in 1578, in Shakespeare's "Henry VI" and others, including one elaborated comment in Secker's "Nonsuch Prof" of 1660: "We say that birds of a feather will flock together. To be too intimate with sinners is to intimate that we are sinners too."

• Quality begets quality and if you want high quality flavors that will survive long shelf life in dry mixes without weakening or deterioration, the answer is

"Sealva Flavors"

Top quality flavors hermetically sealed in dry powdered form for all dry packaged foods. Write for samples, quotations and technical data.

van Ameringen-Haebler, Inc.
521 West 57th Street • New York 19, New York

CHICAGO • LOS ANGELES • TORONTO • PARIS
Plants—Elizabeth and Union Beach, N. J.—Paris

Alva FLAVORS

man & Co., 220 E. 42nd St., New York City. The brochure includes a list of microorganisms against which the paint is effective.

A technical service bulletin describing Zeolex, **an anti-caking agent** for foods and chemicals, has been published by J. M. Huber Corp., 100 Park Ave., New York 17. Zeolex is the trademark for a series of ultra-fine particle size materials used to resist caking in foods and chemicals. Depending on the material being conditioned, it can act as a parting agent, bulking agent, moisture barrier or sponge.

Complete technical data on all types of **filter cloths** are in Bulletin No. 10, offered by National Filter Media Corp., 1717 Dixwell Ave., New Haven, Conn. The data cover chemical resistance, corrosion resistance, abrasion resistance and available yarn forms for more than a dozen natural and artificial fibers.

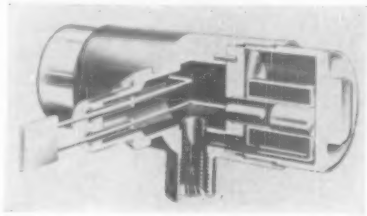
Standards for Polyethylene Extrusion Coating have been officially adopted and published by the Polyethylene Extrusion Coaters Group of the Specialty Paper & Board Affiliates, Inc., 122 E. 42nd St., New York 17.

A 12-page Norelco booklet, giving engineering data on the **newest X-ray instruments** for element analysis and structure determinations, is available free of charge from the Instruments Div., Philips Electronics, Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

(Continued on page 61)

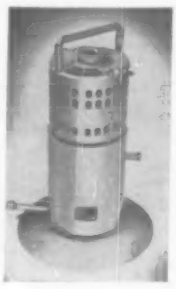
EQUIPMENT

Level Detector. A new detecting device utilizes a special design principle to give high- or low-point indication of liquid, solid or slurry levels. Called the Model CL-10 Dynatrol, it detects product levels by the variation in the output signal from a small paddle vibrating at 120 c.p.s. The output signal can be used to control the operation of any kind of electrical equipment. The design of the instrument allows sensitive transmission of vibrational energy from the driver end to the sensing paddle and back to the output signal end through a linkage path welded to rigid metal pressure seals at the node points, where zero vibration amplitude occurs. The unit is rated for use at pressures up to 3,000 p.s.i.g., and it operates from 115-v. a.c. lines. Construction is explosion-proof and corrosion-resistant, and the device can be mounted in any position; only a ¾-in. NPT pipe opening is required.



Full details can be obtained from Automation Products, Inc., 3030 Max Roy St., Houston 24, Tex.

Lab Vacuum Pumps. For laboratory use, the Arthur F. Smith Co. has produced the new Asco-Vac 10 line of portable, mechanical high vacuum pumps. Features of the new models include high, efficient pumping capacity, clean and quiet operation, gas ballast, and operating economy due to a much smaller volume of oil charge. Free air displacement is 50 liters per minute, with a guaranteed absolute pressure of 0.1 micron with the two-stage units and 30 microns with single stage. Noise is reduced by insulation and rubber mounting, and the vertical design of the units eliminates the hazards of the conventional belt-pulley drive.

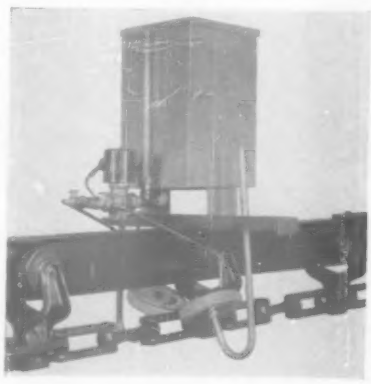


Further details and prices can be obtained from Arthur F. Smith Co., 311 Alexander St., Rochester 4, N. Y.

Sifter-Conveyor. The J. H. Day Co. is offering a special unit for sifting and handling various materials. Called the Day Ro-Ball Airmatic, it is a compact, self-contained, mobile unit that can sift and deliver aerated flour or materials of similar consistency to mixers or storage bins. It serves as a dump bin, Ro-Ball sifter and Airmatic conveyor. One push-button operates the entire system, which is capable of handling more than 100 lb. of material per minute for distances up to 175 ft.

Bulletin B-106-RA, describing the new machine, is available from the J. H. Day Co., Div. of Cleveland Automatic Machine Co., Cincinnati 12.

Conveyer Oiler. Olsen Mfg. Co. is offering a conveyor oiler, automatic in operation, that applies an even film of oil by direct contact with oil-carrying felt rollers. The device is said to be especially advantageous for use on food conveyors, where oil drip must be prevented.



The rollers apply an oil film to each side of the chain simultaneously, and the flow of oil to the rollers is controlled by a solenoid valve that shuts off the oil

supply when the conveyor is halted.

Descriptive literature is available from Olsen Mfg. Co., 638 S. Rochester Rd., Clawson, Mich.

Sensitive Flow Switch. Precise control of liquids is said to be possible with the Pottermeter flow switch. This device, in the one-inch size, will detect flows in the order of one-quarter to one-half gallon per minute, and will activate a switch for indication or control. Compact and designed with in-line flow characteristics, models are available to operate at any line pressure. The switch is explosion-proof, lightweight, and has special design features to permit it to perform under conditions of vibration, shock and extreme temperatures.

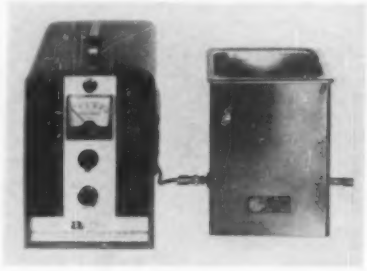
The switch also is capable of detecting reverse flow. It will operate in any attitude in either liquid or gas, and can be completely submerged. Normal operating range is −85° to 550° F., but the unit can be built for operation at higher or lower temperature extremes. It is available in a variety of fittings and metals for special applications. Complete information is offered by the manufacturer, Potter Aeronautical Corp., Route 22, Union, N. J.

Corrosion-Resistant Hand Trucks. Clark Equipment Co. recently announced production of special corrosion-resistant units in its Powrworker line of powered hand trucks. The new units are especially designed for use in food processing plants, cold storage warehouses and other areas where materials handled contain quantities of acids, salts or other corrosive agents.

The anti-corrosion characteristics are obtained through modification of regular Powrworker units. The drive motor, lift limit and deadman switches are totally enclosed. An undercoating protects the bottom of the machine, and a special wiring harness is treated to prevent deterioration of insulation.

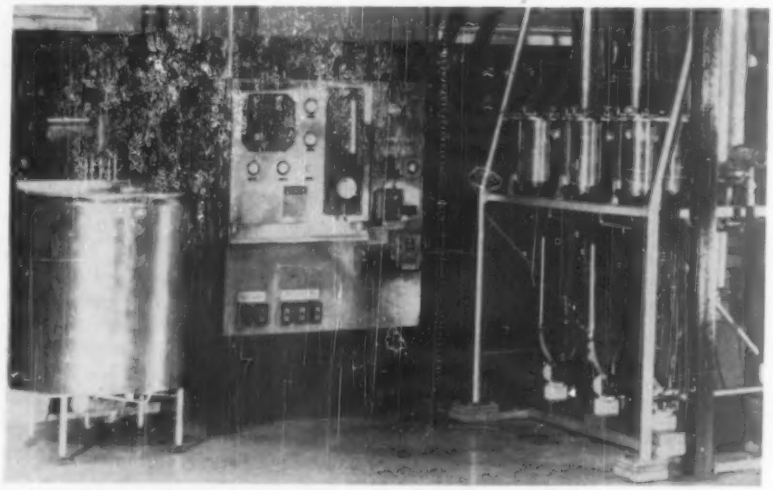
Corrosion-resistant construction can be specified on any model in the Powrworker line at additional cost. For details, write Clark Equipment Co., Battle Creek, Mich.

Ultrasonic Cleaning Unit. Food technologists are offered a new ultrasonic cleaning unit said to be of value in laboratory investigations of chemicals, foods and biologicals. Designed Model DR 50-AH, it consists of a compact generator and a half-gallon tank fitted



with a transducer. Designed for portability, durability and easy maintenance, the device is fitted with an outlet tap for hook-up with an external recirculating filter or temperature control system. The tank can be recessed or flush-mounted in a bench, and the unit operates from standard 115-v. a.c. power lines. Details and prices are available from Acoustic Associates, Inc., Mineola, N. Y.

Electric "Bunsen". Gardner Laboratory, Inc., has produced an electric "bunsen" burner for laboratory and industrial use. Designed to operate from 110-volt a.c. lines, the device has an element temperature range of 800 – 1,000° C., with temperatures easily controllable, and is said to combine the advantages of the gas burner with the cleanliness and ease of control possible only with electric heating. It can be used for heating test tubes, crucibles, small flasks and beakers. The conical working cavity of the heating element, which is replaceable, is designed so that the radiant heat is concentrated and directed upward. Full details and prices are avail-

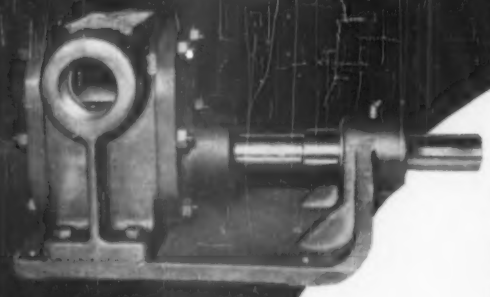


Pilot equipment developed by Chemical Plants Div., Blaw-Knox Co., 300 Sixth Ave., Pittsburgh, for the Carver-Greenfield rendering and drying process, a low-temperature (110-120° F.) process for fats and for production of oleo oils from edible tallow. Blaw-Knox says the process gives practically 100% yield of exceptionally high-grade edible fat and produces an edible low-fat, high-protein meat by-product that is extremely dry and highly stable. The process is continuous, with only a few minutes' contact time under high vacuum.

Eastman CHEMICAL PRODUCTS, INC.

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; New York City; Framingham, Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle; Denver; Spokane; Phoenix. **Canada: P. N. Soden Co., Ltd.,** Montreal, P. Q.; Toronto, Ontario.

NEW TWIN-LOBE® Positive Displacement PUMP*



Manton-Gaulin presents a completely new concept in rotary positive displacement pumping — The Gaulin Twin-Lobe*® design.

The two big features are simplicity and performance — results of a radically new "Twin-Lobe" pumping principle. Look at these advantages:

- Simple construction, only three moving parts.
- High mechanical efficiency, lower horsepower required.
- High vacuum, self-priming. Efficient enough to move volatile gases or extremely viscous liquids.
- Wide range of uses — handles corrosive and abrasive materials.
- Special alloys used throughout for long wear, precision fit.

Send for New G. T. A./TLP-57 Bulletin!

Complete description, data sheets and application guide are now available. Find out how the new Twin-Lobe pump can save money, improve quality.

One Basic Design good for many uses

Liquids, heavy slurries, pastes, soft food solids, emulsions, gases, and light non-lubricating liquids

*Pat. Pending

Capacity and size range

Three models now available. Capacities: 0-56 gpm; Pressures: 0-200 psi.

Gaulin TRADE MARK

MANTON Gaulin

MANUFACTURING CO., INC. EVERETT, MASS.

82 GARDEN ST. EVERETT 49, MASS.

World's largest manufacturers of stainless steel reciprocating, rotary, pressure exchange pumps, dispersers, homogenizers and colloid mills.

able from Gardner Laboratory, Inc., Box 5728, Bethesda 14, Md.

Tank Truck Cleaner. Oakite Products, Inc., has introduced a new device especially designed to clean tank truck compartments. Called the Oakite Spray-O-Mat, it weighs less than 7 lb. and measures less than 2½ in. in diameter. It consists of a hydraulically propelled rotary head which turns on a self-cleaning, hardened stainless steel ball race. The spherical head is fitted with a wide-angle nozzle and is slotted to provide a three-directional spray. Necessary auxiliary equipment includes a pump with a minimum rating of 40 g.p.m. at 60 p.s.i.; pipes and valves; solution and drain hose; and a 100-gal. solution tank.

Full operating details on the Spray-O-Mat, which is available at a nominal rental fee to users of Oakite cleaning compounds, can be obtained by writing Oakite Products, Inc., 19 Rector St. New York 6.

Automatic Selector Valve. New Products Corp., Skokie, Ill., recently introduced a simple type of valve for automatically switching the flow of liquids, under pressure, from one tank to another or from a series of tanks to processing. The selector valve can be inserted in lines where tanks are equipped with individual pumps or where the gravity pressure permits. It will direct the flow of liquid from one or all tanks at the same time, and will automatically seal off any tank when it empties.

When feeding from one tank at a time, the selector valve frees the operator from watching gauges and tanks as critical low points are reached. He can throw in a full tank any time before this point is reached, and both tanks will feed until the first runs dry, at which time the second tank takes over. Such a set-up can include any number of tanks.

The manufacturer says the selector valve, which consists of only three parts, is fully automatic, fast acting and unaffected by temperature, and there is no pressure drop or flow restriction. It has a pressure range up to 100 p.s.i., and can be furnished in a wide range of sizes and metals.

Arthur F. Smith Co., 311 Alexander St., Rochester 4, N. Y., has announced that this Model 700 pilot molecular still now is available for test runs and limited custom distillation. The high-vacuum molecular still, located at the company's Gardiner Park plant in Rochester, is capable of feed rates up to 150 lb. per hour, and can process organic compounds with molecular weights to 1250 and silicones and halocarbons to 4000. Any operation performed on the Model 700 may be duplicated on the Model 7000 production still available from the company.

Reinforced Steam Hose. Now available to the food processing industry is a complete line of wire-reinforced, burst-proof hose for saturated steam service at pressures up to 200 p.s.i. or for superheated steam up to 385° F. Known as Acme W. B. steam hose, it is built around a tube made of special heat-resisting rubber. Reinforcement is provided by one or two braided plies of high-tensile steel wire, each covered by a layer of heat-resistant rubber; these in turn are covered by high-tensile cord yarn, which acts as a bonding layer for the outer neoprene cover. Standard sizes range from ½-in. to 2½-in. I.D.

Additional information on Acme W. B. steam hose can be obtained from Acme Rubber Mfg. Co. Div., Acme-Hamilton Mfg. Corp., 115 Meade St., Trenton 3, N. J.

PRODUCTS

Aluminum Cans. Continental Can Co. was slated to introduce in mid-October a line of aluminum cans in several different styles. In addition to the conventional three-piece and drawn cans that will be commercially available immediately, Continental's announcement said that aluminum cans formed by impact extrusion will be offered early next year.

Initally, according to Gen. Lucius D. Clay, Continental board chairman, the aluminum containers will cost significantly more than conventional tinplate cans. The differential is expected to shrink progressively, however, as aluminum manufacturers are able to trim costs by more efficient production of can stock, and as manufacturing processes are improved.

Continental has been making aluminum cans experimentally for 24 years, General Clay said, and already has turned out several million for commercial tests. "Only this year, however," General Clay added, "has the supply of aluminum begun to approach a point where this material is available in appreciable quantities for the manufacture of cans."

Apart from the making of cans by conventional processes from aluminum plate, Continental foresees a major potential for metal containers in processes new to the can industry, such as impact extrusion and other deep-drawing techniques. The technological experience the company has gained in the fabrication of tinplate cans, General Clay said, will help it adapt these processes to highly precise mass production operations.

Vegetable Protein Flavoring. A new hydrolyzed vegetable protein, especially designed to meet specific flavoring needs in the meat packing industry, has been announced by the Huron Milling Div. of Hercules Powder Co. The new product, Triple-H Seasoning, reportedly will enhance the natural flavor characteristics of products not subject to the high temperatures generally found in the canning industry. It is said to offer valuable possibilities as an ingredient in such meat items as seasoned frozen hamburger patties, meat balls, ham, bacon, corned beef and beef tongue.

Composition of Triple-H Seasoning is: MSG (monosodium glutamate), 6%; HVP (hydrolyzed vegetable protein) flavor solids, 24%; total chlorides, 72%; total solids, 97%. For further information on this product, and recommended uses, write Hercules Powder Co., Virginia Cellulose Dept., Huron Milling Div., Wilmington 99, Del.

(Continued on page 61)

EXPANSION NEWS

The Glidden Co. has begun construction of a $4 million edible protein plant, said to be the world's first facility for commercial production of this important soybean derivative, in Indianapolis. The new protein product will be marketed under the trademark Promine. When incorporated in staple foods, Promine builds up protein levels to considerably higher nutritive standards and imparts many desirable physical characteristics to such products. The soybean-derived protein is the result of intensive research by Glidden's Chemurgy Div., and has been available in limited quantities for the past three years.

Morningstar, Nicol, Inc., New York City, announced recently the acquisition of Federal Adhesives Corp., also of New York City, and its affiliates. Morningstar operates a subsidiary, Paisley Products, Inc., which is one of the larger manufacturers of industrial and packaging adhesives and chemical specialties. The Federal acquisition is in a similar line of business, specialty adhesives, including a manufacturing affiliate in Baltimore, the Adex Mfg. Co., as well as Federal Latex Corp. and Federal Chemicals Corp.

The sales and technical staffs of both companies will continue unchanged, each specializing in its particular field. Key personnel of all Federal organizations have become members of the Morningstar organization.

MEMORANDA

Salary levels of engineering, scientific and administrative employees in American industry rose an average of 5.9% between June 1956 and June 1957, according to a survey conducted by the American Management Association's Executive Compensation Service. This increase is appreciably lower than the 8.6% average salary rise reported for the same group in the previous 12-month period. The study, the fourth annual survey of administrative and technical compensation conducted by the Service, covered rates and ranges of pay for 33,797 employees engaged in 58 major engineering, scientific and administrative activities in 263 companies in the U.S. and Canada.

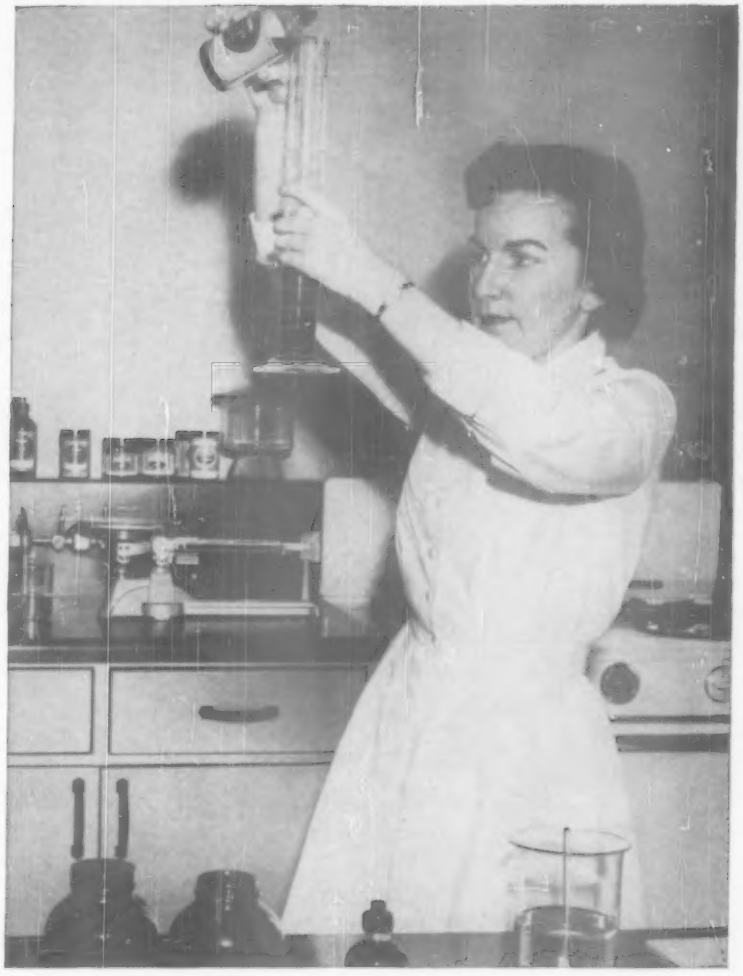
Median annual salaries currently paid to engineers in all fields of activity combined were found to range from about $5,400 in the lowest, or entering, category to approximately $13,100 at the highest non-management level. Salaries of chemists, mathematicians, physicists and other scientists range from a median of $5,400 a year at the beginning level to a median of $14,000 at the highest level. By and large, levels of compensation in Canada for administrative and technical personnel are lower than those prevailing in the U. S. for the same types of jobs.

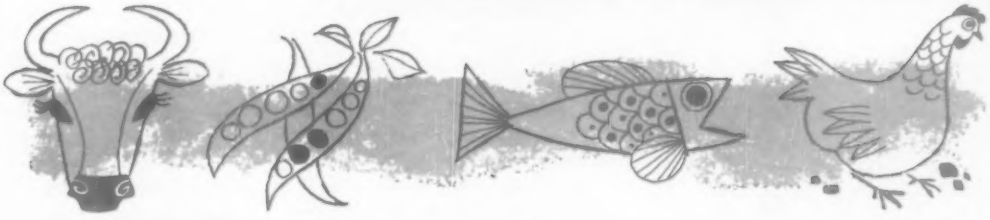
Total pounds of roasted coffee purchased by U. S. housewives during the third quarter of this year were 2% ahead of purchases during the same period of 1956, according to the Pan-American Coffee Bureau. However, of more significance is the fact that sales of regular roasted coffee, in both bags and vacuum cans, continued a slow decline while sales of instant coffee continued to increase at a faster rate. Over the first nine months of the year, regular coffee sales lagged 2.2% behind last year's, while instant coffee climbed 23.1% ahead. Total household purchases of both types of coffee have remained a steady 2.0% ahead of last year's figures.

"Tomorrow's profits depend overwhelmingly on today's success in developing new products," according to Paul S. Willis, president of Grocery Manufacturers of America, Inc. Speaking at the fourth annual New Products Seminar in New York recently, Mr. Willis said that more than 50% of grocery products sales ten years from now could come from items that are non-existent today, if grocery manufacturers continue their present pace of producing new products.

Mr. Willis pointed out that the rapid changes taking place in American living habits spell enormous opportunities for business. However, he warned that "the disturbing trend toward conformity on the part of middle-management people" may keep some companies from moving fast enough to capitalize on favorable conditions. "Under today's fiercely competitive conditions, the passive course which conformists consider safe is really the most unsafe thing in the world for their companies," said the GMA president. He predicted that "creative businessmen," who can combine the qualities of the creative artist and the hard-headed businessman, will move into the top positions of American industry. "Creative businessmen will have due respect for the realities of commerce and the need to run a company at a profit, but at the

new ways to improve your product and profits





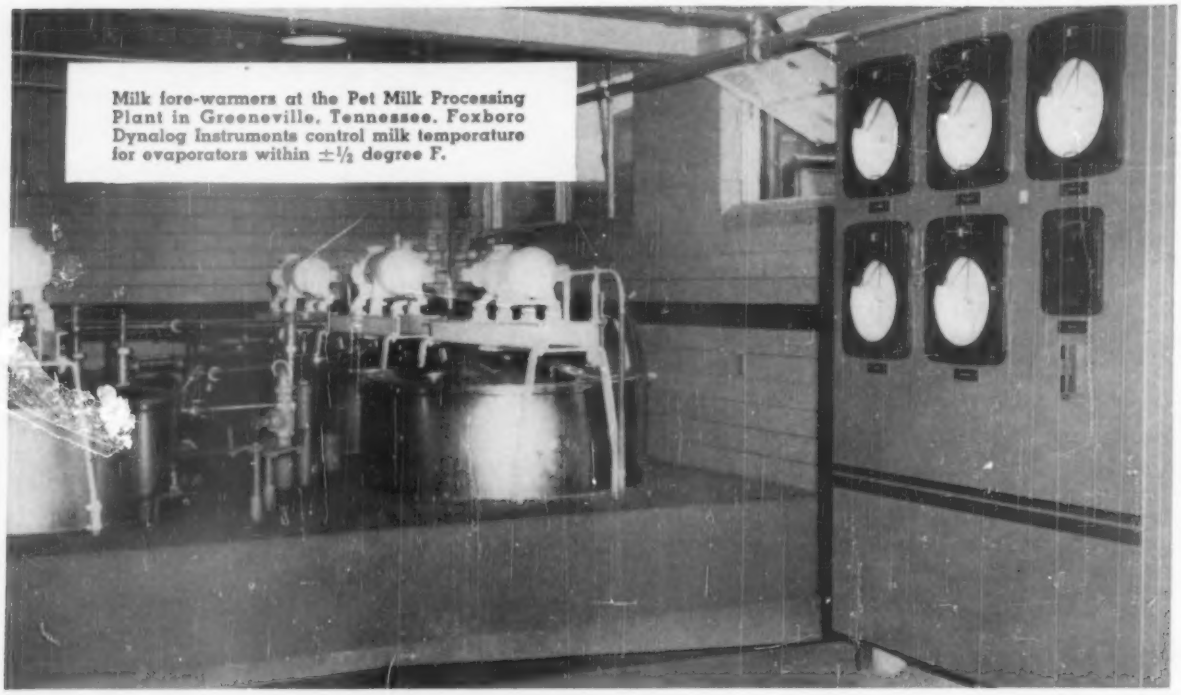
Animal, vegetable, fish or fowl—if your forte is food, Huron HVP® (Hydrolyzed Vegetable Proteins) can help you enhance the quality and broaden the market for your products. This, of course, means extra sales and profits for you. In our modern, well-equipped Technical Service Laboratory, we will be happy to work with you to determine the proper use levels for your individual products.

The new booklet, *"Huron HVP," will give you a wealth of information on specific applications of HVP in all phases of food processing. For your free copy, write, wire or phone Huron Milling Division, Hercules Powder Company, Wilmington 99, Delaware.*

HVP HURON MILLING DIVISION

Virginia Cellulose Department **HERCULES POWDER COMPANY** INCORPORATED *Wilmington 99, Delaware*

SALES OFFICES: 380 MADISON AVENUE, NEW YORK 17, N. Y. • 332 SOUTH MICHIGAN AVENUE, CHICAGO 4, ILL. • 120 MONTGOMERY STREET, SAN FRANCISCO 4, CALIF.



Milk fore-warmers at the Pet Milk Processing Plant in Greeneville, Tennessee. Foxboro Dynalog instruments control milk temperature for evaporators within ±½ degree F.

PET MILK reports: "Better product ...at lower operating cost"

with Foxboro Dynalog* Electronic Temperature Instruments

"Last March we converted our fore-warmers from manual to Foxboro automatic temperature control," reports H. H. Barney, manager of the Pet Milk Processing Plant in Greeneville, Tennessee. "Since then our Dynalog Electronic Instruments have held milk fore-warmer temperatures to within ±½ degree of set point. Control has been simpler and safer. Recording more accurate. And we're making a better product at lower steam cost."

Pet Milk's experience can be your experience. Dynalogs have a sensitivity of 1/100 of 1% of scale and accuracy of better than ¼ of 1% of scale . . . respond almost instantly to the slightest temperature change. Full-scale spans as narrow as 5 degrees can be measured within an over-all range of −100° to +675°F. Fully automatic control is assured by the Dynalog's sensitive pneumatic control action.

For accurate, sensitive, trouble-free temperature measurement and control, look to Foxboro Dynalog Instruments. Bulletin 20-10 tells all about them. Write for it. **The Foxboro Company, 3512 Norfolk St., Foxboro, Mass., U.S.A.**

Reg. U. S. Pat. Off.

DYNALOG DESIGN ASSURES HIGH *SUSTAINED* ACCURACY, TROUBLEFREE PERFORMANCE

Temperature measurement is smooth and continuous with Dynalog Electronic Instruments. There's no slidewire—no sliding contacts to cause step-by-step inaccuracies. Instead, a simple rotary capacitor gives uninterrupted measurement.

Dynalogs are inherently free from "drift" and maintenance problems. No dry cells to standardize... no fast-moving parts to lubricate or replace.

FOXBORO
REG. U.S. PAT. OFF.
DYNALOG
ELECTRONIC INSTRUMENTS

same time they will have the inventive imagination to hurdle the roadblocks of habit."

New topics to be introduced at the ninth **Plant Maintenance & Engineering Conference** reflect the rapidly changing aspects of maintenance in the nation's factories. Prevention of air and water pollution and the impact of automation on maintenance head the list of subjects for the forthcoming sessions, which will be held on the first three days of the Plant Maintenance & Engineering Show, which is set for the International Amphitheatre, Chicago, Jan. 27–30.

Industrial production in the United States is not over-expanded, according to Frederick S. Leinbach, executive vice-president of Riegel Paper Corp., New York. Mr. Leinbach, keynote speaker at the 19th annual forum of the Packaging Institute, said, "If we accept our present consumption as standard need for each of us, the normal population increase alone will shortly overtake our present productive facility. If we also accept the likelihood of our continuing to find that today's conveniences become tomorrow's necessities, then that increase in our standard of living will compound consumer demand further."

PERSONNEL

Robert T. Browning has been named executive vice-president of Wallace & Tiernan, Inc., Belleville, N. J. He will step into his new post on January 1. Mr. Browning has been with the company since 1930, and for the past four years he has directed the sales activities of Wallace & Tiernan's three chemical divisions and the sales and engineering activities of five equipment divisions.

R. T. Browning

use the antioxidant with greatest

carry-through.

Sústane BHA

Whatever your fat-containing product, Sústane BHA gives it greater, longer-lasting protection against rancidity through processing or consumer-use conditions.

Sústane-protected shortening gives cooked food products or prepared mixes the carry-through protection they need to maintain your high standards of quality. Sústane BHA is stable, both thermally and chemically, so that it will protect a fat against the development of rancidity after mixing with any food ingredients and even after baking or frying at elevated temperatures. This means greater shelf life for the many cooked food products containing animal and vegetable fats.

If you make crackers, nuts, potato chips, cereals . . . any fat-containing food product, you have the same assurance that your product is protected against oxidation from the time you process it until your consumers eat it . . . when you use

carries through:
cooking
baking
deep frying

Sústane®

the antioxidant with greatest carry-through

Sústane antioxidants come in several convenient, economical forms for the ultimate in time, labor and money savings. Drop us a line or give us a call. We'll be pleased to give you our recommendations.

UOP

UNIVERSAL OIL PRODUCTS COMPANY
30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U. S. A.

Spencer S. Meilstrup, vice-president and general sales manager of Diamond Crystal Salt Co., St. Clair, Mich., has been elected a director of the company, and another of the firm's vice-presidents, **Russell D. Rudolph,** has been named manager of manufacturing and engineering.

William G. Mason, vice-president in charge of cereal sales and marketing for the Quaker Oats Co., Chicago, has been elected president of the Quartermaster Association for 1957-58. He was chosen at the association's recent annual meeting in San Francisco.

Charles W. Kaufman has been appointed director of research for National Dairy Products Corp. Mr. Kaufman, an IFT member, is also a vice-president and director of research for Kraft Foods, a division of National Dairy.

Dr. Edward F. Kohman, longtime member of and active worker in IFT, was the subject of an interesting article in the July issue of the *Journal of Chemical Education.* Tribute is paid in this excellent article by Dr. E. V. McCollum, Johns Hopkins University, to Dr. Kohman's many contributions to canning and canned products research —tin-iron relationships, can corrosion, vitamin retention (notably vitamin C), the role of enzymes in flavor loss as well as flavor gains, and the objective measurement of flavor. Dr. Kohman is presently in Belgium.

Bringing with him three years of industrial experience in product development and consumer acceptance research work, **F. Miles Sawyer,** Davis, Calif., joins the food technology department staff at the University of Massachusetts November 1, according to an announcement by Dean D. H. Sieling, College of Agriculture, and Dr. W. B. Esselen, Head, Department of Food Technology.

As an assistant professor, he will be in charge of biological work in Hatch Laboratory. Professor Sawyer also will do some teaching in flavor evaluation and work on the effect of processing on nutritive value of foods plus the nutritional value of agricultural by-products.

Philip O'C. White has been named to head the new White Cap & Bond Crown Div. of Continental Can Co. The division resulted from combining Continental's Crown & Cork Div. and its subsidiary White Cap. Co. Mr. White has been president of White Cap Co. since 1953 and a vice-president of Continental

Philip O'C. White

John G. Murray

since the latter acquired White Cap in 1956. The former general manager of the Crown & Cork Div., **John G. Murray,** another Continental vice-president, has been named director of technical development for the parent company. He succeeds Maj. Gen. C. L. Adcock, who retired Aug. 31.

Laurence W. Murphy of Geo. A. Hormel Co. and **Leonard T. Force** of Canada Packers have been named co-winners of the third annual Achievement Award presented by Dodge & Olcott, Inc., for outstanding contributions to the meat industry. Mr. Murphy was cited for a method of sticking nonshackled, immobilized hogs, while Mr. Force received his award for development of "Can-Pak" beef dressing on the rail system.

William H. Stahl has been appointed research manager for McCormick & Co., Baltimore spice and extract house. He formerly headed the analytical chemistry section of the Quartermaster Research & Engineering Center at Natick, Mass.

Dr. W. F. Collins, an IFT member, has been appointed a technical representative on the staff of the Gelatin & Stabilizer Dept. of Swift & Co. at Kearny, N. J. He has been with Swift for eight years in the research laboratory and Technical Products Dept. In his new assignment he will continue to serve the dairy industry, as well as other food fields.

W. F. Collins

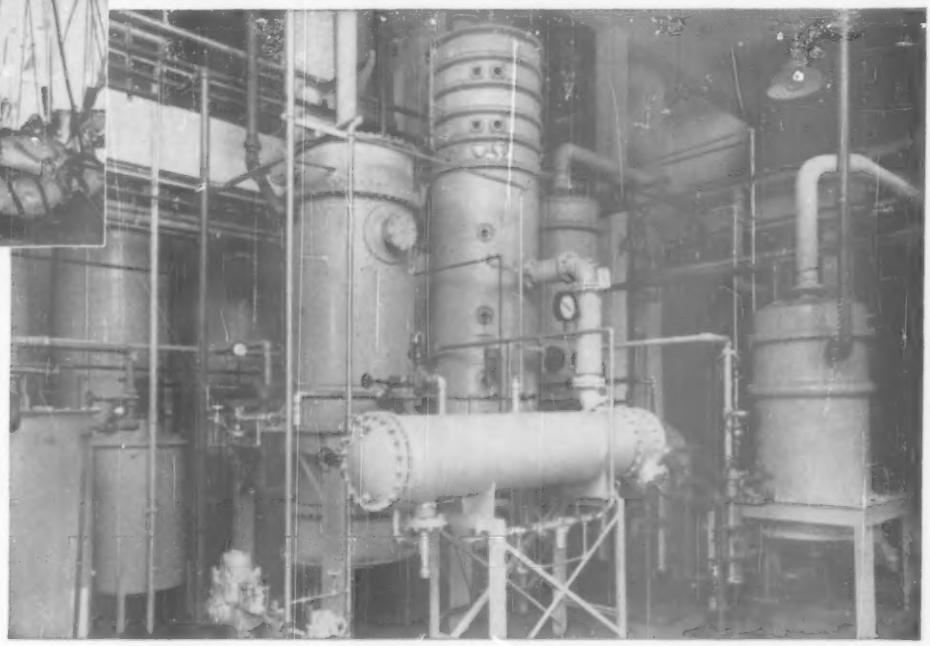
Kenneth G. Voorhees, president of Ungerer & Co., New York City, was presented with a gold watch recently in recognition of 25 years' service to the company. A testimonial luncheon, sponsored by his associates, followed the presentation.

Roy E. Slipiec recently was named midwest sales representative for Geigy Industrial Chemicals division of Geigy Chemical Corp. He will make his headquarters in Chicago.

William J. Gillen, former general manager of Polak & Schwarz, New York City, has been named general sales manager of the firm's Domestic Flavor Div. He has been with the company since 1946.

Tom Ferguson now is a technical consultant with Ever-Rite Equipment Co., Santa Monica, Calif.

Spice Shipments are not always the same...



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George N. Cornell has been named director of a newly created operations research department at the A. E. Staley Mfg. Co., Decatur, Ill., and **Nat Kessler** has been appointed as the firm's chief chemical engineer, the post formerly held by Mr. Cornell.

Rudolp Wehr has joined the research division of the Procter & Gamble Co. He will study the reactions of keratinaceous proteins.

Vern M. Coulson, Oakite Products, Inc., service representative in Evansville, Ind., for 13 years, has been transferred to Fort Worth, Tex., and **Thomas A. Reilly, Jr.,** has been assigned as the firm's representative in Trenton, N. J.

Louis R. Garza has been appointed manager of the International Div. of F. J. Stokes Corp., Philadelphia, maker of high-speed tabletting presses.

IN MEMORIAM

It is with sorrow that we report the death of Mervyn C. Phillips, a Vice President of The Griffith Laboratories of Chicago, who passed away in his sleep the night of October 28th at Ottumwa, Iowa, while on a business trip to that city. Mr. Phillips joined the founders of the Griffith organization—Carroll L. Griffith, President, and the late E. L. Griffith—as their first salesman, in 1921. He resided with Mrs. Phillips at 10601 South Hale Avenue, Chicago. Mr. Phillips held a professional membership in the Institute of Food Technologists. He is survived by his wife, Magdalen, a daughter, Royal, two sons, Mervyn Jr., and Franklin, and three grandchildren.

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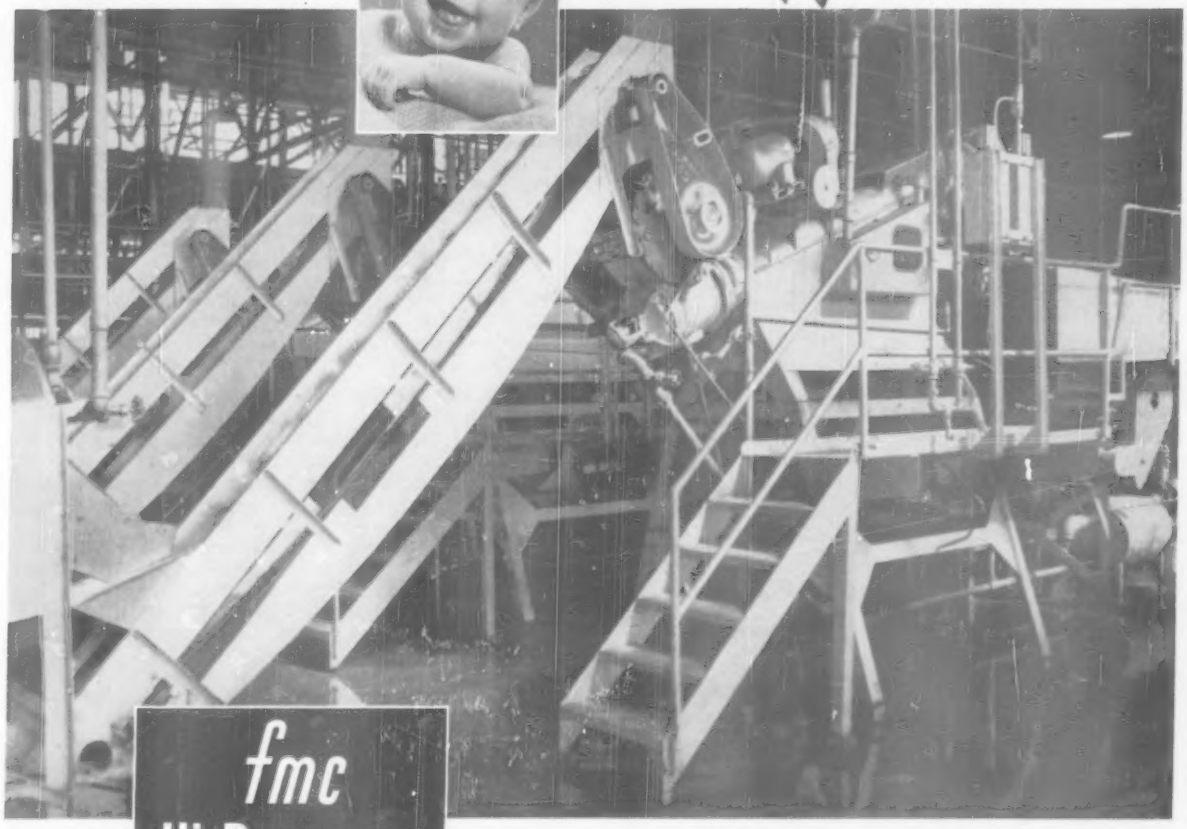
Gentle as a to baby foods



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Write to nearest regional secretary, if within an area covered by a regional section, or to the Executive Secretary of the Institute for an application form and information regarding qualifications and classifications.

INDUSTRY PUBLICATIONS

(Continued from page 47)

Recommendations for Fresh Produce Packaging is the title of a guide published by American Viscose Corp., Film Div., 1617 Pennsylvania Blvd., Philadelphia 3. The pocket-size folder opens into an easily read table that specifies the cellophane types recommended for various produce items according to the style of wrap — direct wrap, tray overwrap or bag.

The Industrial pH Handbook, a new 80-page publication, is said to be the first manual ever published giving such thorough coverage of industrial pH information in a single source. Compiled and edited by Thomas J. Kehoe, application engineering supervisor for the Process Instruments Div. of Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif., the handbook reviews industrial pH control systems, their principles, application engineering and equipment. Included are about 100 illustrations, plus charts, tables and a bibliography of reference literature on pH measurement.

A new detergent for the removal of edible oil residues, Oakite Composition No. 124, is described in a service report recently published by Oakite Products, Inc., 19 Rector St., New York 6. An alkaline detergent reported to have excellent emulsifying and dispersing ability, the new product was formulated for cleaning over-the-road oil tank trucks and deep-fat frying equipment, where soils have dried down or have been baked onto surfaces.

Food processing plant and equipment design engineers will find specific information on the characteristics of **PVC (polyvinyl chloride) pipe** in a 30-page catalog published by A. M. Byers Co., Clark Bldg., Pittsburgh. Properties, applications and installation data of PVC pipe are included, and an eight-page chart compares the corrosion resistance ratings of Types I and II PVC, low carbon steel, three classes of stainless steel and seven other metals with 383 chemicals. The mechanical, thermal and electrical properties of Byers PVC pipe, including ASTM test numbers, are included for basic reference.

Data on **metal-edge filters** are in an illustrated eight-page brochure newly published by Purolator Products, Inc., Rahway, N. J. Descriptions cover filters rated at 1 to 1,000 g.p.m. and able to withstand temperatures from −260° to 1,200° F. The booklet describes their construction, maintenance and types of optional equipment, and tells how to order filters. A flow chart and micron equivalent table also are included.

PRODUCTS

(Continued from page 52)

In most applications, starting recommendations call for the use of 1 lb. of Dolcoseal Onion or Garlic to replace 1 lb. of dehydrated material; in formulas where natural products are used, 1 lb. of Dolcoseal Onion will replace 10 lb. of peeled, trimmed onions, while 1 lb. of Dolcoseal Garlic will replace 5 lb. of peeled, trimmed garlic buds.

Samples are available on request to Dodge & Olcott, Inc., 180 Varick St., New York 14.

Floor, Wall Cleaner. Fine Organics, Inc., is offering free samples of a non-flammable cleaner developed for use on all types of floors as well as for walls, painted surfaces and metal trim. The product, Finorclean, reportedly is an excellent wax remover, is odor-free, and contains no abrasives, acids or solvents. A sample quantity, sufficient to clean 500 sq. ft., is available from Fine Organics, Inc., 211 E. 19th St., New York 3.

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New and expanding research organization is looking for research scientists at the Ph.D. or Master's level to do independent research in the dairy foods field. Education major in dairy technology preferred. Relocation at Company expense to Omaha, Nebraska.

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IRRADIATION—College graduate with background in physical sciences and some knowledge of fundamentals of irradiation to accept assignment in Research Laboratories of a nation-wide food packer. Initial responsibilities to consist of keeping abreast of developments in the field of irradiation of foods. Must be capable of capsuling the rapid developments in this field and translating significance to management. Unlimited opportunities for advancement. Send resumé to BOX 565, Institute of Food Technologists, 176 W. Adams St., Chicago 3, Ill.

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Technical Sales Service Department
CLINTON CORN PROCESSING COMPANY
Clinton, Iowa

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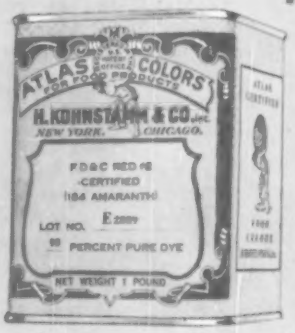
ATLAS *Certified* COLORS

FOR EVERY PURPOSE



New

ATLENE

NON-SEPARATING TYPE
Powdered Certified Colors

100% BASIC COLOR BLENDS
that dissolve as a single color

for

GELATINE DESSERTS
DRY DRINK POWDERS
and other types
DESSERTS and PUDDINGS

STOCK SHADES

ATLENE *Butterscotch Brown*

ATLENE *Cacao Brown (Chocolate Shade)*

ATLENE *Grape Shade*

ATLENE *Lime Shade*

ATLENE *Lemon & Lime Shade*

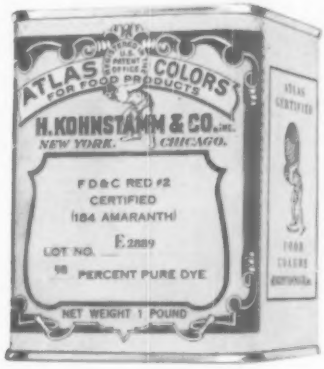
ATLENE *Raspberry Shade*

ATLENE *Root Beer Shade*

ATLENE *Medium Yellow (Egg Shade)*

also

"Custom Made" shades to
suit the individual needs.



STANDARD

ATLAS CERTIFIED COLORS
(Powdered)

Industry's Standard for 105 Years

BASIC COLORS

HERCULES 100%
BASIC COLOR BLENDS

SECONDARY SHADES

plus

many "Custom Made" blends
to meet individual requirements.

also

SELF-MEASURING
COLOR CUBES

PASTE COLORS

LIQUID COLORS

P. G. COLORS
for Summer Coatings and Fillings

New

FLOLENE

CERTIFIED COLOR GRANULES
Non-Dusting Type

FLOLENE Color Granules dissolve readily and with minimum dusting. Thus the possibility of contaminating other products is lessened.

Available in the Following
BASIC COLORS

F D & C	RED	#1
F D & C	RED	#2
F D & C	RED	#3
F D & C	RED	#4
F D & C	YELLOW	#5
F D & C	YELLOW	#6
F D & C	BLUE	#1
F D & C	VIOLET	#1

All other Basic Colors
manufactured in powdered form.

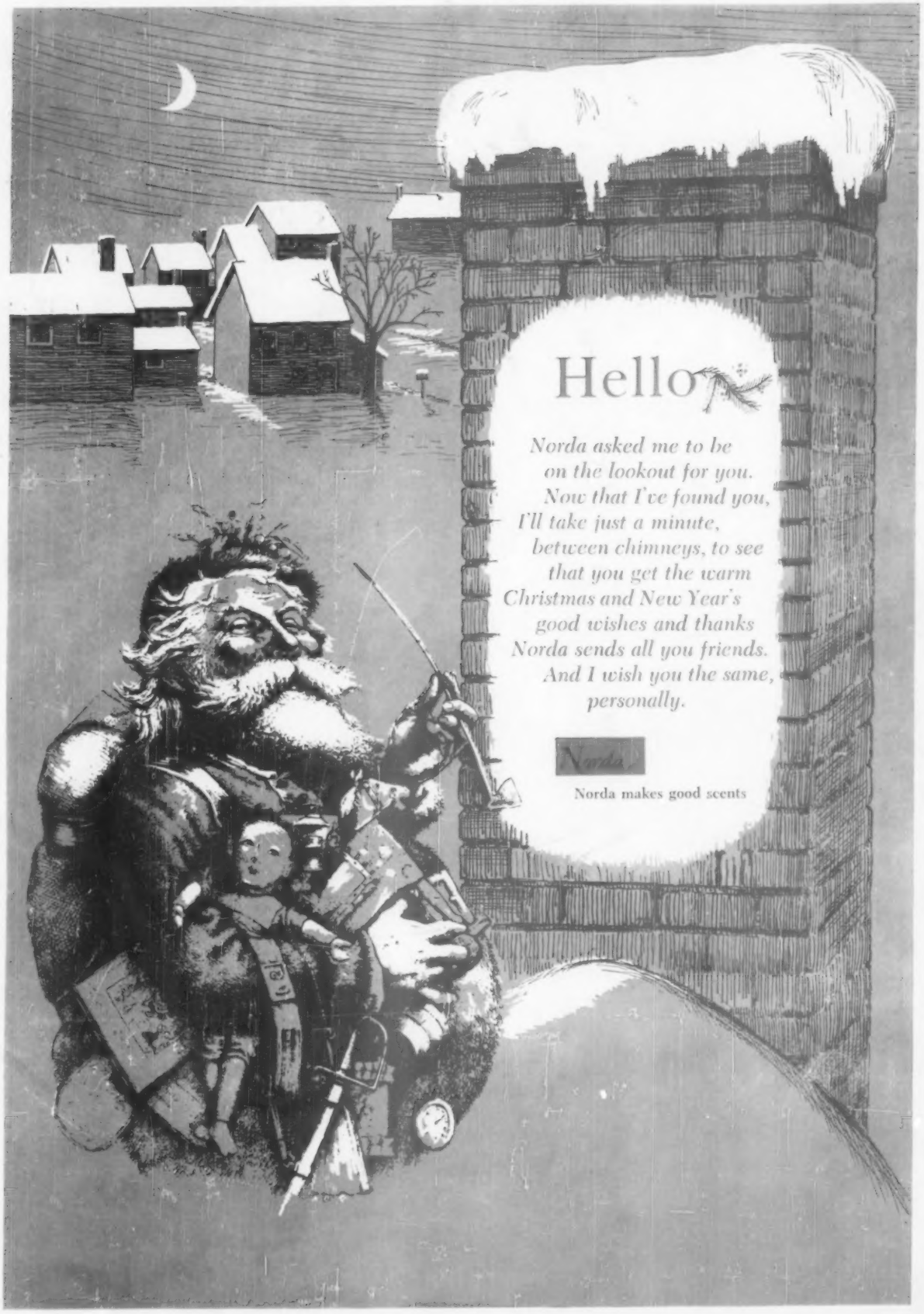
FIRST PRODUCERS OF CERTIFIED COLORS

H. KOHNSTAMM & COMPANY Inc.

ESTABLISHED 1851

89 PARK PLACE, NEW YORK 7 · 11-13 E. ILLINOIS ST., CHICAGO 11 · 2632 E. 54 ST., HUNTINGTON PK., CALIF.

BRANCHES IN OTHER PRINCIPAL CITIES OF THE U.S.A. AND THROUGHOUT THE WORLD


Hello
Norda asked me to be
on the lookout for you.
Now that I've found you,
I'll take just a minute,
between chimneys, to see
that you get the warm
Christmas and New Year's
good wishes and thanks
Norda sends all you friends.
And I wish you the same,
personally.
Norda
Norda makes good scents